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Essays on Non-Price Strategies in Firm Competition

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Essays on Non-Price Strategies in Firm Competition

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Dissertation

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Doctor of Philosophy

The University of Texas at Austin

May 2006

To my parents

Acknowledgments

I am most grateful to Maxwell Stinchcombe for supervising this dissertation. Without his constant advice, guidance and encouragement, I could not have completed my dissertation. I also would like to express my sincere gratitude to him for his wholehearted support. I was most lucky to have him supervise my dissertation. I would like to thank Paul Wilson who gave me warm encouragement and many comments. I am especially grateful to Randal Watson, who critically helped me to develop the second chapter of this dissertation in its initial stage and encouraged me to keep working on it and finish it. I also thank to my committee members, Thomas Wiseman and Andrew Whinston who gave me a lot of comments on my dissertation. I am so grateful to Thomas Wiseman for welcoming and helping me a lot constantly.

I would like to thank Korean colleagues in the economics department. I sincerely thank Jaejoon Han in joy and in sorrow during the whole ph.d program and Jongmin Kim who discussed about my work. I am especially indebted to Eunsook Seo, Jae-young Lee, Hyunjong Kim, Minkyu Song and Myungho Paik. I also thank Hyunkyung Kim, Joonhyung Lee, and Sanghyun Hwang.

I would like to express the deepest appreciation to my mother and father. Their sincere support and patience was an impetus to work for success in this program and my life. I also thank my sisters for their support. My fiancée, Moonhi

Kim, made me to have confidence in my life and keep working on this dissertation. I am especially grateful to her for her patience and support.

Seokhoon Lee

The University of Texas at Austin
May 2006

Essays on Non-Price Strategies in Firm Competition

Publication No. ____________________

Seokhoon Lee, Ph.D.
The University of Texas at Austin, 2006

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This dissertation studies on firm competition in two industries, airline industry and banking industry. Firms compete not only in price but also in non-price strategies. The first essay examines cost structure decision of airlines as a non-price strategy theoretically, and the second essay examines branching decision of banks as a non-price strategy using Korean banking data empirically.

The first essay examines the equilibria of a duopoly game modelling airline competition. Two ex ante identical firms choose a cost structure in the fist stage and then compete in price. I assume that airlines with undifferentiated service (i.e.,

only having one "economy class") have lower costs, while airlines differentiating their products have higher costs. There are three types of subgame perfect equilibria (SPE): symmetric higher-cost SPE, symmetric lower-cost SPE, and asymmetric SPE. Without cost advantages, entry of an airline with undifferentiated service is not profitable. Examples illustrate the market conditions that induce the asymmetric equilibrium in which the two ex ante identical airlines choose different cost structures. I show that in asymmetric equilibria, an airline running a low-cost airplane may have higher profits than an airline running a normal airplane, except when tourists are not price sensitive and the social benefit of business class service is high. Although both the subgame perfect equilibria and the equilibria maximizing social welfare are affected critically by the cost advantage and social benefit of business class service, they differ for some parameter ranges. Not only symmetric equilibria but also asymmetric equilibria may maximize social welfare for some parameters.

The second essay examines the effect of competition between Korean commercial banks with widely divergent branch network structures in the period between 1994 to 1996. It develops a discrete choice model in a competitive framework and allows for banks to choose their deposit interest rate and branch network as well as for depositors to choose a bank for deposit services. The estimates show that branching competition did not change a bank's market power. They also show that regional banks with locally intensive branch networks had much higher markups than did the nationwide banks. The results indicate that overlap between different banks' branch networks increases competition between them and that nationwide banks have a higher cross price elasticity of demand than regional banks. The results show that banks located their branches more in markets with higher branch elasticities.

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Chapter 1

Cost Advantages in Firm Competition: The Airline Markets

1.1 Introduction

> Keith McMullan, of Aviation Economics, a London consultancy, calculates that the low-cost carriers are growing at more than 25% a year (despite the crisis) compared with 4-5% (in normal times) for the European flag carriers....Ryanair's capitalization is now greater than British Airways', following the trend in America, where Southwest Airlines, originator of today's low-cost business model, is worth more than the country's five top mainstream carriers added together. (*The Economist*, 2 March 2002)

Since the deregulation of the U.S. airline industry, Southwest Airlines, one of the low-cost carriers, has become the most successful airline in the industry. While many major airlines make their profits by serving both business class and economy class, low-cost carriers serve only economy class. At the same time it is reported that the major airlines make a substantial proportion of their profits by providing special service for business travellers[1], yet low-cost carriers are still experiencing rapid growth without providing these services.

Low-cost carriers are mainly characterized by point-to-point networks, no-frills service, unreserved seating, lower cost structures[2], and not having business class seats. In the U.S., Southwest Airlines, established in 1971, has been profitable every year since 1973. Recently, many other low-cost carriers, Air Tran, ATA, JetBlue, and Frontier, have also been experiencing rapid growth rates. Low-cost carriers are thriving not only in the U.S. but also in Europe, Canada, and Australia. Ryanair and easyJet are the two fastest-growing low-cost carriers in Europe.

The low-cost carriers' share of US domestic passengers has increased from 7% in 1990 to 23.7% in 2002 (Ito and Lee, 2006), and the growth of the low-cost carriers has created a competitive clash with the major carriers. In particular, the major airline' networks have become highly exposed to the low-cost carriers. According to Ito and Lee (2006), the major airlines made 16.1 to 51 % of their domestic revenue in direct competition with low-cost carriers in 2002. This paper examines competition between low-cost carriers and major airlines in the airline industry. In particular, it models and explains the growth of the low-cost carriers and their market penetration. The paper focuses on three central questions:

1. Under what market conditions do low-cost carriers and major airlines compete with each other in a city-pair market?

2. Under what conditions are low-cost carriers more profitable than major airlines in the market?

[1] "As airlines rely on business travellers for roughly two-thirds of their revenues,..." (*The Economist*, 16 August 2001)

[2] It is reported that they reduce costs by having simple networks, running one type of airplane, reducing labor cost, providing no-frill service, and so on.

3. What is the socially optimal industry cost structure?

Many empirical studies[3] of the airline industry examine the growth of low-cost carriers and the major airlines' responses. Dresner et al. (1996) estimates the impact of the entry of low-cost carriers on route-specific yields and on the yields of competitive routings, with the former having been reduced by 38 per cent and the latter having been reduced by 0 to 41 per cent. Morrison (2001) also estimates passengers' fare savings due to actual, adjacent, and potential competition from Southwest Airlines in 1998. Morrison estimates that the full effect of Southwest was $12.9 billion in savings to passengers, which amounts to 20 per cent of the airline industry's 1998 domestic passenger revenue. Boguslaski et al. (2004) investigate Southwest's entry strategies throughout the 1990s. They find evidence that Southwest entered into medium-haul markets (i.e. 600-1200 miles) as well as very dense short-haul markets (i.e. less than 600 miles). Although the empirical literature provides insights about low-cost carriers' pricing strategies, their entry patterns and consumer welfare, there exists no theoretical literature, to my knowledge, predicting the airlines' equilibrium entry and pricing strategies and evaluating them from the social welfare perspective. In particular, the purposes of this paper are to examine the existence of an asymmetric equilibrium as well as symmetric equilibria[4], to identify the market conditions that give rise to those different equilibria, and finally to identify socially optimal cost structure equilibria.

While much previous literature[5] has focused on the firm's optimality of pro-

[3]e.g., Ito and Lee (2006), Morrison (2001), Dresner et al. (1996), Boguslaski et al. (2004), and so on.

[4]It is known that airplanes with differentiated seat classes, like those run by the 'major airlines', cost more to run than airplanes with undifferentiated seat class, like those run by 'low-cost carriers'. There may exist an equilibrium in which ex ante identical airlines choose different cost structures in a city-pair market. That is, one will choose to differentiate seats and the other will not. I call it as an "asymmetric equilibrium". Likewise, there may exist two types of "symmetric equilibria" in which ex ante identical airlines choose the same differentiated seats cost structure or the same undifferentiated seats cost structure.

[5]Katz (1984) examines competition among multi-product firms with firm-specific differentia-

viding vertically differentiated products in an oligopoly with a symmetric cost structure, in the airline industry, whether or not to offer differentiated service is a crucial strategic choice. There are cost savings due to specialization in economy class, such as is done by the low-cost carriers. This paper examines the role of this different cost structure on the airline's optimality of providing vertically differentiated services (i.e. the coexistence of low-cost carriers having undifferentiated service with the major airlines having differentiated services) and the profitability of low-cost carriers in the airline industry.

This paper models two ex ante identical airlines' choice of airplanes with different cost structures and price competition in a two-stage duopoly game. Thus, it endogenizes the airlines' multi-product decisions by assuming that the airlines can choose whether or not to differentiate their seats in the first stage. I find that there exist three types of subgame perfect equilibria, the type of which varies according to the parameters. In asymmetric equilibria, an airline running a low-cost airplane may have higher profits than an airline running a normal airplane except when tourists are not price sensitive and the social benefit of business class service is high. Not only symmetric equilibria but also asymmetric equilibria may maximize social welfare for some parameters.

The paper proceeds as follows. In Section 2, the basic assumptions and model are introduced. Section 3 presents the airlines' equilibrium prices in the second

tion. Assuming symmetric cost structures, he shows that multi-product firms have an incentive to compete less fiercely for products with lower quality due to a self-selection constraint maintaining high price of the products with high quality. Gilbert and Matutes (1993) and Verboven (1999) also provide a theoretical analysis of brand competition with multiple qualities. Gilbert and Matutes (1993) assume that heterogeneous consumers are continuously distributed not only between two brand firms but also between two different qualities. They show that competitive price discrimination forces both firms to markup different quality goods to the same level under the assumption of continuous distribution of heterogeneity. On the other hand, Verboven (1999) shows that premium products have larger percentage markups than base products in the brand rivalry model with limited consumer information. Other references for competition of multi-product firms are Armstrong and Vickers (2001), Corts (1998), Holmes (1989), and Johnson and Myatt (2003).

stage game. Section 4 presents the SPE and their properties through examples, and compares some of the second stage equilibrium profits. Section 5 finds the socially optimal mix of cost structures. The final section concludes.

1.2 The model

I set a two-stage duopoly model. I assume that two ex ante identical airlines, A and B, run their own flights between a pair of cities one time per one day and each operates only one airplane. In the first stage, airlines A and B, choose either a "normal" airplane, that is, one with differentiated seats, or a "low-cost" airplane, that is, one with only economy class seats. In the second stage, the airlines compete in Bertrand fashion. A normal airplane is assumed to have the marginal costs of serving economy class, c , and of serving business class, $c + c_H$. A low-cost airplane is assumed to have the marginal cost, c_E, where $c_E < c < c + c_H$.

Airlines A and B are assumed to operate their flights at different times; for instance, airline A's flight departs at 8:00 am and airline B's flight departs at 10:00 am. I assume that consumers' preferences over the departure times are uniformly distributed between 8:00 am and 10:00 am. Airline A with an 8:00 am flight is located at $d_A$and the airline B with a 10:00 am flight is located at d_B, each of which is assumed to be at the extreme point of a linear city following the Hotelling model.

I assume that two types of consumers, say, business travellers and tourists, are characterized by the following parameters: their location, f , their opportunity cost of saving time, z_θ (z_b for business travellers, z_t for tourists), and their additional willingness to pay for business class, V_θ (V_b for business travellers, V_t for tourists)[6]. f is uniformly distributed over $[d_A, d_B]$. I assume there exist N consumers. Business

[6] z_θ denotes the degree of horizontal differentiation and V_θ denotes the degree of vertical differentiation. The two types of consumers are defined by their sensitivities to these two differentiated services

travellers ($\theta = b$) occur with the probability, $\frac{\beta}{1+\beta}$, and tourists ($\theta = t$) occur with the probability, $\frac{1}{1+\beta}$. Business travellers are assumed to have much higher costs than tourists, $z_b > z_t$, for unit deviation of d_A (or d_B) from their locations. Assuming that airlines A and B are located at $d_A = 0$ and $d_B = 1$, a type $(\theta,\ f)$ of consumer has a utility function $U(p : \theta, f) = w + V_\theta - z_\theta|f - d_i| - p^i_{bu}$ if he or she buys an airline i's business class service at p^i_{bu} and $U(p : \theta, f) = w - z_\theta|f - d_i| - p^i_{ec}$ if he or she buys an airline i's economy class service at p^i_{ec}, where p^i_{bu} and p^i_{ec} are the prices of the airline i's business and economy classes respectively and $p_{bu} = (p^i_{bu}, p^{-i}_{bu})$, $p_{ec} = (p^i_{ec}$, $p^{-i}_{ec})$. The reservation price, w, is assumed to be so large that all travellers will purchase an airline's service in equilibrium.

Assumption 1 *$V_b > c_H > V_t$.*

Assumption 1 implies that the business traveller's utility increase for an upgrade to business class service from economy class service is greater than the airline's cost increase. In contrast, the tourist's utility increase for the upgraded service is less than the airline's cost increase.

An airline's choice of a normal airplane in the first stage will be denoted by "B/E", for "Business and Economy", and an airline's choice of a low-cost airplane will be denoted by "E", for "Economy". Given $s \in S$, an airline's strategy in the first stage, where $S = \{(B/E, B/E), (E, E), (E, B/E), (B/E, E)\}$, the equilibrium prices, $(p^{i*}(s), p^{j*}(s))$ are $\arg\max\ \pi^i(p^i(s), p^j(s))$, where $(p^{i*}(s), p^{j*}(s)) = \{(p^{i*}_{bu}(s), p^{i*}_{ec}(s)), (p^{j*}_{bu}(s), p^{j*}_{ec}(s))\}$, $i = A, B$ and $i \neq j$, .

The subgame perfect equilibria (SPE) may exist as follows: there may exist a symmetric SPE, $\Big\{(B/E, B/E)\,, (p^{A*}(1), p^{B*}(1)); (\pi^{A*}_{B/E}(1), \pi^{B*}_{B/E}(1))\Big\}$ – Case 1 in which both airlines provide both business class and economy class seats $(B/E, B/E)$, there may exist a symmetric SPE, $\big\{(E, E)\,, \big(p^{A*}(2), p^{B*}(2)\big)\,; (\pi^{A*}_{E}(2), \pi^{B*}_{E}(2))\big\}$ – Case 2 in which both airlines provide only economy class seats (E, E), and there may exist an asymmetric SPE, $\left\{(E, B/E), (p^{A*}(3), p^{B*}(3)); (\pi_E^{A*}(3), \pi_{B/E}^{B*}(3))\right\}$ – Case 3 in which only one airline, call it A, provides both business class and economy class seats $(B/E, E)$.

Airline A \ Airline B	(B/E)	(E)
(B/E)	$(\pi_{B/E}^{A*}(1),\ \pi_{B/E}^{B*}(1))$	$(\pi_{B/E}^{A*}(3),\ \pi_E^{B*}(3))$
(E)	$(\pi_E^{A*}(3),\ \pi_{B/E}^{B*}(3))$	$(\pi_E^{A*}(2),\ \pi_E^{B*}(2))$

Table 1.1: A Reduced Normal Form Game

The reduced normal form game in Table 1 illustrates the airlines' payoffs in the first stage based on the equilibrium profits in the second stage. Each airline chooses its strategy in the first stage, based on the payoffs in the reduced normal form game. A SPE with Case 1 in the second stage would exist if $\pi_{B/E}^{i*}(1) \geq \pi_E^{i*}(3)$, $i = A, B$. A SPE with Case 2 in the second stage would exist if $\pi_E^{i*}(2) \geq \pi_{B/E}^{i*}(3)$, $i = A, B$. A SPE with Case 3 in the second stage would exist if $\pi_{B/E}^{i*}(3) \geq \pi_E^{i*}(2)$ and $\pi_E^{j*}(3) \geq \pi_{B/E}^{j*}(1),\ i = A, B\ and\ j \neq i$.

1.3 The second stage equilibrium

In this section I derive the Nash-Bertrand equilibrium for each case determined by airlines' choices of airplanes in the first stage. The airlines would be faced with one of the following three scenarios: Case 1 in which each airline chooses a normal airplane; Case 2 in which each airline chooses a low-cost airplane; and Case 3 in which airline A chooses a normal airplane and airline B chooses a low-cost airplane.

Lemma 1 *Let Assumption* 1 *hold. If an airline, say* $i = A, B$, *chooses a normal airplane, then* $p_{bu}^i - p_{ec}^i = V_b$ *dominates* $p_{bu}^i - p_{ec}^i > V_b$ *and* $p_{bu}^i - p_{ec}^i = V_t$ *dominates* $p_{bu}^i - p_{ec}^i < V_t$. *Therefore,* $V_b \geqq p_{bu}^i - p_{ec}^i \geqq V_t$ *is the range of the undominated prices.*

Note that it is optimal for two different type of consumers to buy different services in this range of undominated prices. Thus, Assumption 1 eliminates the equilibria in which an airline providing both classes of service sets its prices such that both types of consumers choose the same class of service[7].

1.3.1 Case 1: Both airlines chooses normal airplanes.

Here, I examine the Hotelling price competition between airlines serving both business class and economy class. A consumer with (θ, f) maximizes her utility by purchasing an airline's service that solves $\max_{i,k}(w + V_\theta - z_\theta|f - d_i| - p_k^i)$, where $i = A, B$, given the set of prices, $\{(p_{bu}^A, p_{ec}^A), (p_{bu}^B, p_{ec}^B)\}$.

Demand for each airline's services can be derived from both types of consumers' utility maximization problems. Let $\hat{f}_b$ be the business traveller who is indifferent between airlines A and B, that is, such that $w + V_b - z_b\hat{f}_b - p_{1bu}^A = w + V_b - z_b(1 - \hat{f}_b) - p_{1bu}^B$. Then, $\hat{f}_b = \left(\frac{z_b + p_{1bu}^B - p_{1bu}^A}{2z_b}\right)$, and the business travellers located in $[0, \hat{f}_b]$ prefer buying airline A's business class service to airline B's business class service, and airline B's is preferred to airline A's for business travellers in $[\hat{f}_b, 1]$. Tourists located in $[0, \hat{f}_t]$, $\hat{f}_t = \left(\frac{z_t + p_{1ec}^B - p_{1ec}^A}{2z_t}\right)$, have a higher utility for airline A's economy class service than airline B's economy class service, and airline B provides higher utility to tourists in $[\hat{f}_t, 1]$ than airline A.

Lemma 2 *Suppose that all airlines serve both classes. If Assumption* 1 *holds and* $z_b - z_t > V_b - c_H$, *then* $p_{bu}^{i*} = p_{ec}^{i*} + V_b$, $i = A, B$ *in equilibria.*

Lemma 2 implies that when business travellers are price insensitive relative to tourists, the airline serving both classes might have a binding self-selection constraint in setting prices for both classes.

[7]There might exist cases in which it is optimal for an airline to separate two types of consumers even if Assumption 1 does not hold, $V_t > c_H$. However, I focus on the cases in which Assumption 1 holds.

As shown in Theorem 1, in the absence of a binding self-selection constraint, equilibrium prices are determined only by costs and horizontal differentiation. With a binding self-selection constraint, each equilibrium price is affected by costs and both horizontal and vertical differentiation. In other words, there exist competition spillovers between two classes of services.

Theorem 1 *Suppose that all airlines serve both classes and Assumption* 1 *holds. If* $z_b - z_t \leq V_b - c_H$, *then equilibrium prices are* $p_{bu}^{i*} = c + c_H + z_b$, $p_{ec}^{i*} = c + z_t$, $i = A, B$. *If Assumption* 1 *holds and* $z_b - z_t > V_b - c_H$, *then equilibrium prices are* $p_{bu}^{i*} = c + \frac{\{(1+\beta)z_b - \beta(V_b - c_H)\}z_t}{z_b + \beta z_t} + V_b$, $p_{ec}^{i*} = c + \frac{\{(1+\beta)z_b - \beta(V_b - c_H)\}z_t}{z_b + \beta z_t}$, $i = A, B$.

Corollary 1 *Suppose all airlines serve both classes and Assumption* 1 *holds. When* $z_b - z_t \leq V_b - c_H$, $(p_{1bu}^{i*} - c - c_H) - (p_{1ec}^{i*} - c) = z_b - z_t$, *and when* $z_b - z_t > V_b - c_H$, $(p_{1bu}^{i*} - c - c_H) - (p_{1ec}^{i*} - c) = V_b - c_H$, $i = A, B$.

$V_b - c_H$ is the social welfare increase from providing upgraded business class service to business travellers and thus might be a maximum markup difference between business class and economy class services in equilibrium. Corollary 1 shows that the difference between the equilibrium markups for business class and economy class services is the lesser of $z_b - z_t$ and $V_b - c_H$. Thus, the markup difference between two classes is determined by $z_b - z_t$ when competition for business travellers and for tourists is similar (i.e. $z_b - z_t \leq V_b - c_H$), while the markup difference between two classes is determined by $V_b - c_H$ when competition for business travellers and for tourists is very different (i.e. $z_b - z_t > V_b - c_H$).

1.3.2 Case 2: Both chooses low-cost airplanes.

I derive the price equilibrium in Case 2 in which airlines A and B compete for both types of consumers, with only economy class service. A consumer with (

$\theta,\ f)$ chooses an airline's economy class service such that it would make $w - z_\theta|f - d_i| - p^i_{ec} \geq w - z_\theta|f - d_j| - p^j_{ec}$ where $i, j = A, B$ and $j \neq i$. Then, the demand each airline has is $\frac{\beta N}{1+\beta}(\frac{z_b + p^j_{ec} - p^i_{ec}}{2z_b})$ from business travellers and $\frac{N}{1+\beta}(\frac{z_t + p^j_{ec} - p^i_{ec}}{2z_t})$ from tourists, where $i, j = A, B$ and $j \neq i$.

Theorem 2 *Suppose both airlines serve only economy class. The equilibrium prices are* $p^{i*}_{ec} = c_E + \frac{(1+\beta)z_b z_t}{(z_b+\beta z_t)}$, $i = A, B$.

When both airlines serve only economy class, the equilibrium prices depend on the ratio of business travellers to tourists and both types of consumers' price sensitivity.

1.3.3 Case 3: One airline chooses a normal airplane and the other airline chooses a low-cost airplane.

I now derive the price equilibrium in Case 3 in which airline A chooses a normal airplane and airline B chooses a low cost airplane. A consumer with $(\theta,\ f)$ choosing an airline i's economy class service would have consumer surplus $w - z_\theta|f - d_i| - p^i_{ec}$ where $i = A, B$, while the consumer choosing airline A's business class service would have consumer surplus $w + V_\theta - z_\theta|f - d_A| - p^A_{3bu}$. By Lemma 2, a business traveller with $(\theta = b,\ f)$ will choose between airline A's business class and airline B's economy class in equilibrium. Let $\hat{f}_b$ be such that $w + V_b - z_b\hat{f}_b - p^A_{bu} = w - z_b(1 - \hat{f}_b) - p^B_{ec}$. Then, business travellers located in $[0, \hat{f}_b]$, $\hat{f}_b = \left(\frac{z_b + V_b + p^B_{ec} - p^A_{bu}}{2z_b}\right)$, will have higher utility for airline A's business class than for airline B's economy class and vice versa. By Lemma 2, a tourist with $(\theta = t, f)$ will choose between the two airlines' economy class services in equilibrium. Let $\hat{f}_t$ be such that $w - z_t\hat{f}_t - p^A_{ec} = w - z_t(1 - \hat{f}_t) - p^B_{ec}$. Then, tourists located in $[0, \hat{f}_t]$, $\hat{f}_t = \left(\frac{z_t + p^B_{ec} - p^A_{ec}}{2z_t}\right)$, will prefer buying airline A's economy class to airline B's economy class and vice versa.

Theorem 3 *Suppose that airline A provides both classes of service and that airline B provides only economy class service, and Assumption 1 holds.*

If $z_b - z_t \leq V_b - c_H$, then airlines' equilibrium prices are

$$
\begin{aligned}
p_{bu}^{A*} &= c - \frac{c - c_E}{3} + \frac{c_H + V_b}{2} + \frac{1}{2}(z_b + \frac{(1+\beta)z_b z_t}{(z_b + \beta z_t)}) - \frac{\beta(V_b - c_H)z_t}{6(z_b + \beta z_t)}, \\
p_{ec}^{A*} &= c - \frac{c - c_E}{3} + \frac{1}{2}(z_t + \frac{(1+\beta)z_b z_t}{(z_b + \beta z_t)}) - \frac{\beta(V_b - c_H)z_t}{6(z_b + \beta z_t)}, \ \ \textit{and} \\
p_{ec}^{B*} &= c_E - \frac{c_E - c}{3} + \frac{(1+\beta)z_b z_t}{z_b + \beta z_t} - \frac{\beta(V_b - c_H)z_t}{3(z_b + \beta z_t)}.
\end{aligned}
$$

If $z_b - z_t > V_b - c_H$, then airlines' equilibrium prices are

$$
\begin{aligned}
p_{bu}^{A*} &= c - \frac{c - c_E}{3} + \frac{(1+\beta)z_b z_t}{z_b + \beta z_t} - \frac{2\beta(V_b - c_H)z_t}{3(z_b + \beta z_t)} + V_b, \\
p_{ec}^{A*} &= c - \frac{c - c_E}{3} + \frac{(1+\beta)z_b z_t}{z_b + \beta z_t} - \frac{2\beta(V_b - c_H)z_t}{3(z_b + \beta z_t)}, \ \ \textit{and} \\
p_{ec}^{B*} &= c_E - \frac{c_E - c}{3} + \frac{(1+\beta)z_b z_t}{z_b + \beta z_t} - \frac{\beta(V_b - c_H)z_t}{3(z_b + \beta z_t)}.
\end{aligned}
$$

When its self-selection constraint does not bind ($z_b - z_t \leq V_b - c_H$), airline A's equilibrium price for each type of class would be determined only by horizontal differentiation of its own type of consumers in Case 1, as shown in Theorem 1. In contrast, even in absence of binding self-selection constraint, airline A's equilibrium price for each class reflects horizontal differentiation of the both type of consumers in Case 3. The reason is that its rival, airline B provides only economy class service for both type of consumers in Case 3. When $z_b - z_t > V_b - c_H$, airline A's equilibrium prices are set under a binding self-selection constraint, as in Case 1.

1.4 The first stage game equilibrium (SPE)

1.4.1 Structure of the SPE

Subgame perfect equilibria are illustrated in the following example. Let $\beta = 0.25$, $z_b = 4$, $V_b = 4$, $c = 4$ and $c - c_E = 0.5$. Then, the cost advantages enjoyed by low-cost airplanes are relatively small, 12.5 percent of c or V_b. Let z_t and c_H range from 0.25 to 4, so that they would vary in a rectangular area $[0 - 3.75,\ 0 - 3.75]$[8].

Figure 1.4.1 shows that three types of SPE each exist somewhere in the range of $(z_b - z_t,\ V_b - c_H)$[9] and social benefit from business class, $V_b - c_H$, critically affects the type of SPE. Symmetric SPE in which the two ex ante identical airlines choose the same higher cost structure, normal airplanes, exist when social benefit from business class is high, while symmetric SPE in which they choose the same lower cost structure, low-cost airplanes, exist when social benefit from business class is low. Strikingly, when social benefit from business class is moderate, there exist asymmetric SPE in which ex ante identical airlines choose different cost structures.

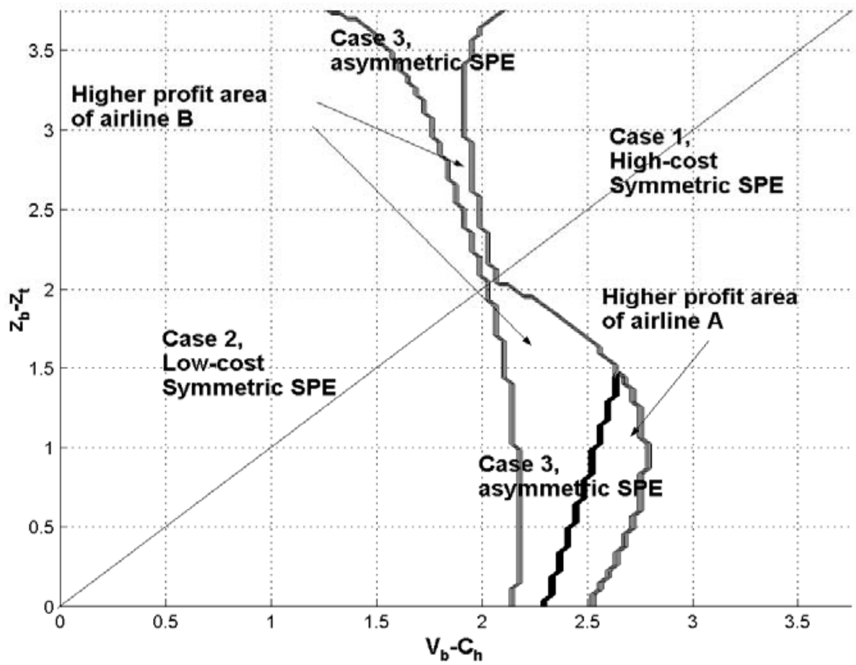
Let $z_b - z_t > V_b - c_H$, with parameter ranges in the upper-left part of Figure 1.4.1. The boundary between the SPE with Case 1 and the SPE with Case 3 and boundary between the SPE with Case 2 and the SPE with Case 3 are mostly downward sloping[10]. This implies that as tourists' price sensitivity increases ($z_t \downarrow$), the airlines are more likely to choose a normal airplane.

Note that when $z_b - z_t > V_b - c_H$, $\frac{\partial p_{bu}^{i*}(1)}{\partial z_t} = \frac{\partial p_{ec}^{i*}(1)}{\partial z_t} < \frac{\partial p_{bu}^{A*}(3)}{\partial z_t} = \frac{\partial p_{ec}^{A*}(3)}{\partial z_t} <$

[8] By excluding cases in which tourists are extremely price sensitive, I did not consider the SPE in which airline A running a normal airplane serves only business class against airline B running a low-cost airplane.

[9] Note that $z_b - z_t$ represents the difference between the two types of consumers' price sensitivity, associated with horizontal differentiation, and $V_b - c_H$ represents the difference between business travellers' welfare increase and its cost, say, "social benefit from business class", associated with vertical differentiation.

[10] Boundary between the SPE with Case 1 and the SPE with Case 3 are upward sloping when tourists' price sensitivity, z_t, is very low.



Above 45° line, self-selection constraints are binding.

Figure 1.1: Subgame perfect equilibria

$\frac{\partial p_{ec}^{B*}(3)}{\partial z_t} < \frac{\partial p_{ec}^{i*}(2)}{\partial z_t}$, $i = A, B$[11]. That is, the effect of an increase in the tourists' price sensitivity on the equilibrium prices is largest in SPE with Case 2, while it is smallest in SPE with Case 1. The intuition behind this is that when tourists' price sensitivity increases, airlines running normal airplanes would reduce their prices less than airlines running low-cost airplanes due to their incentive to maintain the business traveller markup. Thus, for lower value of z_t, the airlines' choice of a normal airplane incurs less tight competition, relative to a low-cost airplane. This makes airlines more likely to choose a normal airplane.

[11] I assume that airline A chooses a normal airplane and airline B chooses a low-cost airplane in a SPE with Case 3. When $z_b - z_t > V_b - c_H$, (i) $\frac{\partial p_{bu}^{i*}(1)}{\partial z_t} = \frac{\partial p_{ec}^{i*}(1)}{\partial z_t} = \frac{(1+\beta)z_b^2 - \beta(V_b - c_H)z_b}{(z_b+\beta z_t)^2}$, (ii) $\frac{\partial p_{ec}^{i*}(2)}{\partial z_t} = \frac{(1+\beta)z_b^2}{(z_b+\beta z_t)^2}$, (iii) $\frac{\partial p_{bu}^{A*}(3)}{\partial z_t} = \frac{\partial p_{ec}^{A*}(3)}{\partial z_t} = \frac{3(1+\beta)z_b^2 - 2\beta(V_b - c_H)z_b}{3(z_b+\beta z_t)^2}$, $\frac{\partial p_{ec}^{B*}(3)}{\partial z_t} = \frac{3(1+\beta)z_b^2 - \beta(V_b - c_H)z_b}{3(z_b+\beta z_t)^2}$, where $i = A, B$.

Although its low-cost airplane choice incurs tighter competition, airline B may choose a low-cost airplane for very low values of z_t (high $z_b - z_t$). Note that when z_t decreases, demand for airline B running a low-cost airplane increases much faster at lower value of z_t[12]. This may make its low-cost airplane choice more profitable even in tighter competition. Hence, for very low values of z_t, there exists an upward sloping boundary between the SPE with Case 1 and the SPE with Case 3.

Let $z_b - z_t \leq V_b - c_H$, with parameter ranges in the lower-right part of Figure 1.4.1. The boundary between the SPE with Case 1 and the SPE with Case 3 results in a convex curve. The boundary between the SPE with Case 2 and the SPE with Case 3 also does.

Note that when $z_b - z_t \leq V_b - c_H$, $\frac{\partial^2 p^*(2)}{(\partial z_t)^2} < \frac{\partial^2 p^*(3)}{(\partial z_t)^2} < \frac{\partial^2 p^*(1)}{(\partial z_t)^2} = 0$[13]. That is, prices in equilibria with Case 2 are the most concave in z_t, while those in equilibria with Case 1 are the least concave in z_t. Note that the price decrease at low values of z_t attracts tourists much more than that at high values of z_t. Thus, an airline running a low-cost airplane, attracting both types of consumers with only economy class service, would reduce its price more when z_t is low and decreasing than when z_t is high and decreasing. That is, an airline's choice of a low-cost airplane incurs less tight competition than a normal airplane for high values of z_t, while it incurs tighter competition for low values of z_t. Hence, when z_t is high and decreasing, airlines are more likely to choose a low-cost airplane, which yields an upward sloping boundary. When z_t is low and decreasing, airlines are more likely to choose a normal airplane,

[12] Note that $\frac{\partial D_{bu}^{A*}(3)}{\partial z_t} = \frac{\beta(V_b - c_H)}{6(z_b + \beta z_t)^2}$ and $\frac{\partial D_{ec}^{A*}(3)}{\partial z_t} = \frac{c - c_E}{6 z_t^2} - \beta \left\{ \frac{\beta(V_b - c_H)}{6(z_b + \beta z_t)^2} \right\}$ and thus $\frac{\partial^2 D_{bu}^{A*}(3)}{(\partial z_t)^2} < 0$ and $\frac{\partial^2 D_{ec}^{A*}(3)}{(\partial z_t)^2} < 0$.

[13] When $z_b - z_t \leq V_b - c_H$, (i) $\frac{\partial p_{bu}^{i*}(1)}{\partial z_t} = 0$, $\frac{\partial p_{ec}^{i*}(1)}{\partial z_t} = 1$, (ii) $\frac{\partial p_{ec}^{i*}(2)}{\partial z_t} = \frac{(1+\beta) z_b^2}{(z_b + \beta z_t)^2}$, (iii) $\frac{\partial p_{bu}^{A*}(3)}{\partial z_t} = \frac{3(1+\beta) z_b^2 - \beta(V_b - c_H) z_b}{6(z_b + \beta z_t)^2}$, $\frac{\partial p_{ec}^{A*}(3)}{\partial z_t} = \frac{1}{2} + \frac{3(1+\beta) z_b^2 - \beta(V_b - c_H) z_b}{6(z_b + \beta z_t)^2}$, $\frac{\partial p_{ec}^{B*}(3)}{\partial z_t} = \frac{3(1+\beta) z_b^2 - \beta(V_b - c_H) z_b}{3(z_b + \beta z_t)^2}$, where $i = A, B$.

which yields a downward sloping boundary.

Note that except when $z_b - z_t$ is small and $V_b - c_H$ is large, airline B has higher profit than airline A in the SPE with Case 3. Figure 1.4.1 shows parameter area in which airline B has higher profit than airline A in the SPE with Case 3. Intuitively, for high tourists' price sensitivity, an airline running a low-cost airplane can attract tourists easily at a little lower price, maintaining its high markup due to its cost advantage. When social benefit from business class is large, an airline running a normal airplane can set a high price for business class due to business travellers' high willingness to pay for upgrade to business class.

1.4.2 Profits, prices, and demands in the SPE

As in the Figure A.1[14], the profit of an airline rises or drops discontinuously when its rival changes the type of airplane, which makes the boundary between different types of SPE. In contrast, airlines changing their type of airplane have continuous profits at the boundary. This suggests that depending on the rival's airplane type, an airline should be faced with different degree of competition.

Theorem 4 *Suppose that* $z_b - z_t > V_b - c_H$. *Then,* $p_{ec}^{A*}(2) \leq p_{ec}^{A*}(3) \leq p_{ec}^{A*}(1)$ *and* $p_{bu}^{A*}(3) \leq p_{bu}^{A*}(1)$, *if and only if* $c - c_E \geq \frac{\beta(V_b - c_H)z_t}{z_b + \beta z_t}$. *Suppose that* $z_b - z_t \leq V_b - c_H$. *Then,* $p_{ec}^{A*}(3) \leq p_{ec}^{A*}(1)$, *if and only if* $c - c_E \geq \frac{\beta\{3(z_b - z_t) - (V_b - c_H)\}z_t}{2(z_b + \beta z_t)}$, *and* $p_{ec}^{A*}(2) \leq p_{ec}^{A*}(3)$, *if and only if* $c - c_E \geq \frac{\beta\{3(z_b - z_t) + (V_b - c_H)\}z_t}{4(z_b + \beta z_t)}$. $p_{bu}^{A*}(3) \leq p_{bu}^{A*}(1)$, *if and only if* $c - c_E \geq \frac{2\beta(V_b - c_H)z_t + 3\{(V_b - c_H) - (z_b - z_t)\}z_b}{2(z_b + \beta z_t)}$.

Theorem 4 implies that the entry of low-cost carriers either decreases or increases prices. When cost advantage is large, the entry of low-cost carriers decreases both business class price and economy class price. Note that when social benefit

[14]Figures A.1, A.2, A.3, A.4, A.5, A.6, A.7 and A.8 can be found in Appendix A.3. In those figures, I assume that airline A runs a normal airplane and airline B runs a low-cost airplane in the SPE with Case 3.

from business class is high and tourists are price insensitive, the entry of low-cost carriers increases the business class price, as shown in the Figure A.2 showing airline A's equilibrium prices. Figures A.2 and A.3 show that the entry of low-cost carriers decreases all economy class prices.

Theorem 5 *Assume that* $\beta = 0.25$, $z_b = 4$, $c = 4$ *and* $c - c_E = 0.5$. *Let* $(D_{bu}^{i*}(3), D_{ec}^{i*}(3))$, $i = A, B$, *represent demands in asymmetric equilibrium in which airline A runs a normal airplane and airline B runs a low-cost airplane. Then,* $\frac{D_{bu}^{A*}(3)}{D_{bu}^{A*}(3)+D_{bu}^{B*}(3)} (\equiv \tilde{D}_{bu}^{A*}(3)) > \frac{D_{ec}^{A*}(3)}{D_{ec}^{A*}(3)+D_{ec}^{B*}(3)} (\equiv \tilde{D}_{ec}^{A*}(3))$. *When* $z_b - z_t \leq V_b - c_H$, $\frac{\partial D_{bu}^{A*}(3)}{\partial z_t} > 0$ *and* $\frac{\partial D_{ec}^{A*}(3)}{\partial z_t}|_{z_t = z_b} < 0$, $\frac{\partial D_{ec}^{A*}(3)}{\partial z_t}|_{z_t = \tilde{z}_t} = 0$ *and* $\frac{\partial^2 D_{ec}^{A*}(3)}{(\partial z_t)^2} < 0$ *where* $\tilde{z}_t = \sqrt{\frac{3\beta(1+\beta)z_b - \beta^2(V_b - c_H)}{2(c - c_E)}} - \beta$. *When* $z_b - z_t > V_b - c_H$, $\frac{\partial D_{ec}^{A*}(3)}{\partial z_t} > 0$ *and* $\frac{\partial D_{bu}^{A*}(3)}{\partial z_t} > 0$.

Figure A.4 shows the demand of airline A's business and economy class services in the subgame perfect equilibria. Each airline has the same demand in the symmetric SPE with Case 1 and Case 2 regardless of z_t, while airlines' demands in the SPE with Case 3 varies with z_t. As shown in Theorem 5, when $z_b - z_t > V_b - c_H$ and thus its self-selection constraint is binding, demand for both of airline A's classes decreases as tourists' price sensitivity increases. In contrast, when $z_b - z_t \leq V_b - c_H$ and thus the self-selection constraint does not bind, demand for airline A's economy class may increase and demand for business class decreases as z_t decreases.

1.4.3 The SPE with some changed parameters

This subsection investigates the changes of the SPE, incurred by changes of some parameters, β and $c - c_E$. Finally, Figure A.5 and A.6 show subgame perfect equilibria and equilibria maximizing social welfare, respectively, when $\beta = 0.35$. The area representing asymmetric SPE and the area representing asymmetric equilibria maximizing social welfare shifts left, implying that as the proportion of business travellers increases, a normal airplane providing both classes is more likely to be chosen in both SPE and socially optimal cost structures equilibria.

Figure A.5 and A.6 show subgame perfect equilibria and equilibria maximizing social welfare, respectively, when $c - c_E = 0.6$. When cost advantage increases, the entry of low-cost carriers is more likely to happen given consumer parameters. However, note that almost all properties of the SPE in the above still maintain regardless of β's and $c - c_E$'s changes.

Figure A.9 and A.10 show subgame perfect equilibria and equilibria maximizing social welfare, respectively, when $z_t = 1$ and $z_b \in [1, 5]$. As in Figure 1.4.1, when $z_b - z_t$ is not large, asymmetric SPE are more likely to exist. That is, when tourists are very price sensitive, an airline running a low-cost airplane can not get high economy class markup and thus is not profitable.

1.4.4 Comparison of the second stage equilibrium profits

The second stage equilibrium profits vary with the parameters representing consumer preferences and costs (i.e. β, $V_b - c_H$, z_b, z_t, and $c - c_E$)[15]. In particular, Theorem 3 shows some feasible comparisons between the second stage equilibrium profits[16]. Recall that $p^*(s)$ is the equilibrium price when the cost structure in the second stage is $s \in S = \{1, 2, 3\}$.

Lemma 3 *Let Assumption* 1 *hold. When* $z_b - z_t \leq V_b - c_H$, *the equilibrium profit functions have the following relations;* (*i*) $\pi^i_{B/E}(p^*(1)) - \pi^i_{B/E}(p^*(2)) = \frac{N}{1+\beta}\left\{\frac{\beta(z_b - z_t)^2}{2(z_b + \beta z_t)}\right\}$, $\forall i = A, B$, (*ii*) *if* $c - c_E < \frac{\beta(V_b - c_H) z_t}{z_b + \beta z_t}$, *then* $\pi^B_E(p^*(3)) < \pi^B_E(p^*(2))$, *and* (*iii*) *if* $c - c_E > \frac{\beta(V_b - c_H) z_t}{z_b + \beta z_t} + 3\left\{\sqrt{z_b z_t} - \frac{(1+\beta) z_b z_t}{z_b + \beta z_t}\right\}$, *then* $\pi^B_E(p^*(3)) > \pi^B_{B/E}(p^*(1))$,

[15] Equilibrium prices, demands, and profits for all cases in the second stage are put in Appendix A.2

[16] Note that a subgame perfect equilibrium should be determined through comparisons of the second stage equilibrium profits in Table 1.

where $p^*(1)$, $p^*(2)$, *and* $p^*(3)$ *are the equilibrium prices of Case 1, Case 2, and Case 3. When* $z_b - z_t > V_b - c_H$, *they also have the following relations;* (iv) $\pi^i_{B/E}(p^*(1)) - \pi^i_E(p^*(2)) = \frac{N}{1+\beta}\left\{\frac{\beta(V_b-c_H)(z_b-z_t)}{2(z_b+\beta z_t)}\right\}$, $\forall i = A, B$, (v) *if* $c - c_E < \frac{\beta(V_b-c_H)z_t}{z_b+\beta z_t}$, *then* $\pi^B(p^*(3)) < \pi^B(p^*(2))$, *and* (vi) *if* $c - c_E > \frac{\beta(V_b-c_H)z_t}{z_b+\beta z_t} + 3X$, *then* $\pi^B(p^*(3)) > \pi^B(p^*(1))$, *where* $X = \frac{\sqrt{((1+\beta)z_b z_t)^2+\beta(V_b-c_H)(z_b-z_t)z_b z_t}}{z_b+\beta z_t} - \frac{(1+\beta)z_b z_t}{z_1+\beta z_t}$.

Theorem 3 (i) and (iv) imply that as long as tourists are more price sensitive than business travellers, each airline earns a higher profit in Case 1 (separating consumers) than in Case 2 (pooling consumers). Nonetheless, it is shown through examples in the above subsection that there may exist a SPE with Case 2, if there is a cost advantage of running a low-cost airplane. According to Theorem 3 (ii) and (v), when $c - c_E < \frac{\beta(V_b-c_H)z_t}{z_b+\beta z_t}$, airline B (low-cost airplane) has a higher profit in Case 2 in which it is competing against a rival with low-cost structure than in Case 3 in which it is competing against a rival providing both classes of service. This suggests that as its cost advantage gets smaller, a low-cost carrier might prefer competing against another low-cost carrier to competing against an airline with both classes. Theorem 3 (i), (iii), (iv) and (vi) imply that if $c = c_E$, then the ex ante identical airlines in the first-stage game will make their choice of a normal airplane the dominant strategy. Thus, Theorem 6 suggests that entry of the low-cost carriers could be achieved through the cost advantages of the low-cost carriers.

Theorem 6 *Suppose that* $c = c_E$. *Then, there does not exist a symmetric SPE with Case 2 or a SPE with Case 3.*

According to Theorem 7, derived from Theorem 3 (iii) and (vi) and Theorem 4, the economy class prices drop when airline B changes to a low-cost ariplane, from the SPE with Case 1 to the SPE with Case 3, and airline A changes to a low-cost airplane, from the SPE with Case 3 to the SPE with Case 2.

Theorem 7 *$p_{ec}^{A*}(3) \leq p_{ec}^{A*}(1)$ in the boundary between the SPE with Case 1 and the SPE with Case 3, and $p_{ec}^{A*}(2) \leq p_{ec}^{A*}(3)$ in the boundary between the SPE with Case 2 and the SPE with Case 3.*

1.5 Social welfare analysis

In this section, I examine the airlines' cost structures that maximize social welfare. I consider a social planner problem in which the social planner chooses the airlines' cost structures and then the airlines compete in the Hotelling model. The social planner's problem is

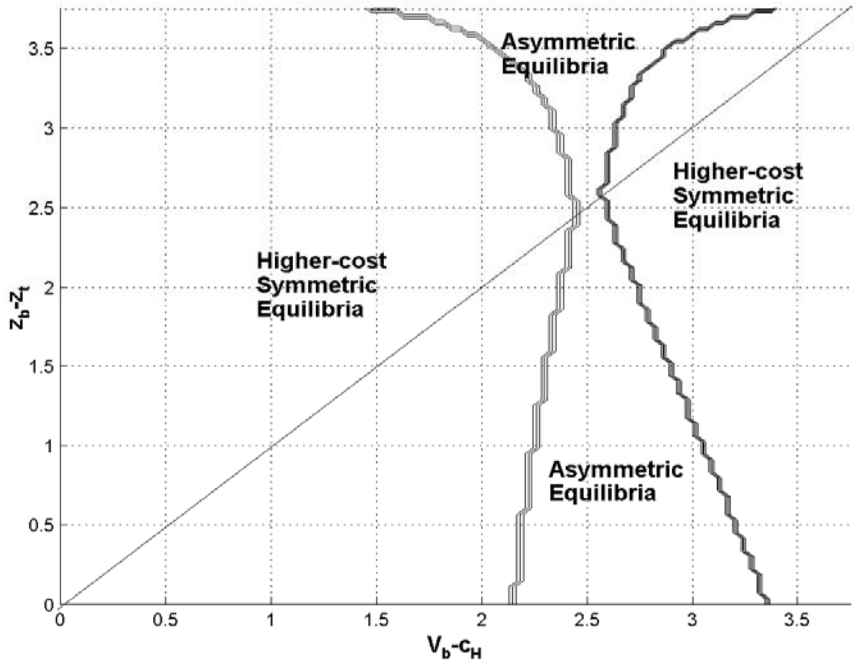
$$\max_s SW(s) = (\pi^{A*}(p^*(s) + \pi^{B*}(p^*(s)) + CS(p^*(s)),$$

where $s \in S = \{(B/E, B/E), (E, E), (E, B/E), (B/E, E)\}$ and $p^*(s)$ and $CS(p^*(s))$ are the second-stage equilibrium prices and aggregate consumer surplus respectively.

A consumer with (θ, f) would have $w - z_\theta|f - d_i| - p_{ec}^i$ from purchasing an airline i's economy class service, while she would have $w + V_b - z_\theta|f - d_i| - p_{bu}^i$ from purchasing an airline i's business class service. Then, aggregate consumer surplus at equilibrium prices in the airlines' cost structures, $s \in S$, is

$$\begin{aligned} CS(p^*(s)) = \frac{\beta N}{1+\beta}\{&\int_0^{f_{bu}^*(s)} (w - z_b f - p_{ec}^{A*}(s) + 1(bu)(V_b + p_{ec}^{A*}(s) - p_{bu}^{A*}(s)))df \\ &+ \int_{f_{bu}^*(s)}^1 (w - z_b(1-f) - p_{ec}^{B*}(s) + 1(bu)(V_b + p_{ec}^{B*}(s) - p_{bu}^{B*}(s)))df\} \\ + \frac{N}{1+\beta}\{&\int_0^{f_{ec}^*(s)} (w - z_t f - p_{ec}^{A*}(s))df + \int_{f_{ec}^*(s)}^1 (w - z_t(1-f) - p_{ec}^{B*}(s))df\}. \end{aligned}$$

Figure 2 shows that symmetric higher cost equilibria maximize social welfare when $V_b - c_H$ is high and symmetric lower cost equilibria do when $V_b - c_H$ is low.



Above 45° line, self-selection constraints are binding.

Figure 1.2: Equilibria with cost structures maximizing social welfare

It is notable that there also are parameter ranges in which asymmetric equilibria maximize social welfare.

Ignoring the costs incurred to consumers due to airline's deviation from their most preferred location, it would be socially desirable for all tourists to choose airline B's economy class service and all business travellers to choose airline A's business class service when $c - c_E < V_b - c_H$ and it would be socially desirable for both type of consumers to choose airline B's economy class service when $c - c_E \geq V_b - c_H$. From this perspective, note that when $c - c_E < V_b - c_H$, any symmetric equilibria cause misallocation between consumer types and the desirable airplane types[17]. I call

[17]Note that when $c - c_E \geq V_b - c_H$, there is no misallocation in the SPE with Case 2. In those parameter ranges, I found the symmetric lower-cost equilibria (the SPE with Case 2) socially optimal.

the cost from the undesirable allocation "the misallocation cost". Theorem 5 shows that asymmetric equilibria may reduce the misallocation cost and thus increase social welfare, since the proportion of business travellers choosing airline A's business class is greater than that of tourists choosing its economy class[18]. Note that consumers' costs from the airline's deviation from their most preferred location are minimized in each symmetric equilibria. I call the cost from the airline's deviation "the airline deviation cost". As a result, asymmetric equilibria may incur the airline deviation cost more than symmetric equilibria. Nonetheless, Figure 1.5 shows that there exist asymmetric equilibria maximizing social welfare, implying that the decrease in the misallocation cost in the asymmetric equilibria may be greater than the increase in the airline deviation cost.

Let $z_b - z_t \leq V_b - c_H$. According to Theorem 5, when $z_t > \tilde{z}_t$ and z_t increases, demand for airline A's business class is increasing and demand for its economy class is decreasing. Thus, as z_t increases, the misallocation cost decreases in asymmetric equilibria. Figure 1.5 shows that as z_t increases, the area of the asymmetric equilibria maximizing social welfare increases, implying that the decrease in the misallocation cost is greater than the increase in the airline deviation cost[19].

Let $z_b - z_t > V_b - c_H$. By Theorem 5, as z_t decreases, the demand for airline A's both classes decreases. Figure 1.5 shows that as z_t decreases, the area of the asymmetric equilibria maximizing social welfare increases, implying that the decrease in the misallocation cost from tourists dominate the increase in the airline deviation cost.

[18] If the proportions of business travellers and tourists choosing airline A are the same as in the symmetric equilibria, the social welfare achieved in the asymmetric equilibria should be less than the one achieved in either symmetric equilibria.

[19] Note that when $z_t < \tilde{z}_t$ and z_t decreases, airline A's economy demand in asymmetric equilibria is decreasing. Therefore, as z_t decreases, the misallocation of tourists reduces, which may increase the area of asymmetric equilibria maximizing social welfare.

1.6 Conclusions

The entry and growth of the low-cost carriers are a puzzle, given the profitability of serving business travellers. This paper has explained the coexistence of two types of airline services, differentiated and undifferentiated, in the airline industry. In particular, it has focused on the long-run equilibrium of the airline industry by endogenizing ex ante identical airlines' choices of airplanes with different cost structures. I showed that there exist three types of subgame perfect equilibria and without cost advantages, entry of low-cost carriers serving an undifferentiated product would not be profitable.

In reality, low-cost carriers and major airlines have entered and exited in many city-pair markets. Nonetheless, it is known that major airlines cluster in medium and long haul markets, while low-cost carriers cluster in short haul markets. It is reported that low-cost carriers have started to enter the medium haul markets and have succeeded there during the past decade. The model shows that asymmetric equilibria exist when the social benefit of business class service or cost advantage (savings) is moderate. It also shows that symmetric higher cost equilibria exist when the social benefit of business class service is large or the cost advantage is small, while symmetric lower cost equilibria exist when the social benefit of business class service is small or the cost advantage is high. Although the relation between the social benefit of business class service and the travelling distance is an issue to estimate, it seems to be correlated.

I expained the entry of low-cost carriers into hub-spoke markets of major airlines and their growth by showing that an airline running a low-cost airplane has higher profits than an airline running a normal airplane in the most parameters of the asymmetric equilibria, when tourists are somehow price sensitive or when social benefit of business class service is not much high.

I showed that both subgame perfect equilibria and equilibria maximizing social welfare are affected critically by the cost advantage and social benefit of business class service and they are coincident each other in many parameters. In particular, I showed that asymmetric equilibria reduce the misallocation between desirable airplane types and traveller types found in symmetric equilibria.

My analysis limits the airlines' choice of cost structures to either a low-cost airplane or a normal airplane. It would be interesting to analyze three types of airplanes – a normal airplane, a low-cost airplane and a business airplane[20]. I conjecture that there may be another types of asymmetric equilibria, in which an airline running a business airplane and an airline running a normal airplane compete, or in which an airline running a business airplane and an airline running a low-cost airplane compete.

[20]The economist (Oct. 13, 2005) reported that two new carriers, 'eos' and 'Maxjet', providing only business class service, would enter the transatlantic route between London and New York.

Chapter 2

Measuring the Effect of Branch Network in the Korean Banking Industry

2.1 Introduction

In Korea, before 1980, only a few nationwide commercial banks competed under government regulation. Regional banks that entered the market in the late 1960s were restricted to locating their branches only in their own provinces. With government deregulation in the 1980s, many new nationwide banks entered the market. As a result, Korean banks had widely divergent branch networks by the mid-1990's[1]. The purpose of this paper, then, is to find out how the widely divergent branch network structures affected the banks' market powers in the period between 1994 and 1996.

[1]From 1990 to 1996, the total number of branches of all commercial banks increased by more than two times – from 2,032 to 4,606 total branches. The number of branches ranges from 90 to 444 for nationwide banks and from 45 to 201 for regional banks in 1996

The banking industry is characterized by differentiated services. Banks compete for depositors by providing various services such as deposit services, easy access, consulting, foreign exchange, bill payment, and other services. For instance, having a superior branch network to other banks would provide depositors with much closer access and thereby potentially increase a bank's competitiveness. Recently, several papers (Dick, 2002, Adams et al., 2004, Knittel and Stango, 2003) started to apply a differentiated product demand model to the banking industry. Although many issues regarding banks' branch activities have been debated in the banking industry, those papers nonetheless do not address the strategic aspects of banks' branching activities in demand estimation.

Cerasi et al. (2002) and Pinho (2000) focus on the effect of deregulation on branching activities and deposit interest rates by modelling the banks' strategic choices of branch network. Grzelonska (2005) confirms the importance of branch networks, showing the positive effect of the proximity of branches on the level of deposits per branch, and Knittel and Stango (2004) and Ishii (2004) examine the effect of interconnection pricing of ATM network on competition, consumer welfare, and the investment of ATM network. Although they are concerned with the strategic aspects of banks' branch networks, they do not examine the effect of banks' branch networks on competition between banks. To my knowledge, there is no prior analysis of the relationship between a bank's branch network and its market power (price competition) in the banking industry through the modelling of a bank's choice of branch networks as well as deposit interest rates.

This paper builds on a discrete choice demand model in an equilibrium framework (Berry et al., 1995, Draganska and Jain, 2004) to model the bank's choices of deposit interest rate and branch network as well as depositors' choices of which bank to use for deposit services. I use a generalized method of moments to estimate the system of equations in the model, including supply-side equations as well as demand-side equation. The demand equation to estimate is obtained by modelling the depositor's optimal choice of a bank for deposit services. The bank's first order conditions of deposit interest rates and branch networks for profit maximization yields the supply equations. These allow for the bank's optimal choice of deposit interest rates to be associated with their branch activities. This modelling strategy provides an explicit estimation of cost parameters, the improvement of estimation efficiency by allowing for correlation between disturbances, and reveal the interdependency between deposit interest rates and branch network. Commercial banks in Korea can be divided into three categories of banks, according to their branch network structures[2]. All estimated results are analyzed based on the average values within three categories of banks with widely divergent branch networks.

The results indicate that all the coefficients of deposit services, such as branch density, staffing, the bank's age, and provision of foreign exchange, are positive. Recently established branches attract relatively few depositors, implying that depositors have switching costs. Based on the logit results, the estimated markups vary from 2.2% (medium-sized banks) to 2.3% (big 6 banks) and 2.8% (regional banks). The estimated coefficient for the deposit interest rate in the logit model yields the price elasticity of demand 2.5-4.0[3]. Interestingly, the estimated markups and price elasticity of demand are the largest for regional banks with 'intensive' branch network that locates many branches in a few markets. It suggests the close relationship between a bank's branch network and its price elasticity of demand. The estimated markups and price elasticities were stable over the period (1994-1996), implying

[2]There are two categories of nationwide banks divided by entry year, and regional banks. I will call nationwide banks established before 1980 the "big 6 banks", due to high branch network sizes, and nationwide banks established after 1980 the "medium-sized banks".

[3]The Lerner index as a market power index is the inverse of the price elasticity and it shows 0.30-0.31 for big 6 banks, 0.25-0.27 for medium-sized banks, and 0.37-0.39 for regional banks, indicating that regional banks have the highest Lerner index and big 6 banks have higher Lerner index than medium-sized banks.

that branching competition did not change markups or market power.

Based on the estimated cross price elasticity of demand, a change in the deposit interest rate of nationwide banks affects the demand of other nationwide banks much more than that of regional banks. But, those change of regional banks rarely affects any other banks. The results suggest that overlap between different banks' branch networks increases competition between them.

The results indicate that banks established their branches more in markets with higher branch elasticities. Regional banks have a higher branch density than other categories of banks, given the same branch elasticity, which is ascribed to their lower cost of branch and higher markup. The estimated concave preference over branch density may give an explanation for nationwide banks' 'extensive' branch network that locates small number of branches in many markets.

This paper is organized as follows. Section 2 gives a review of the related literature. Section 3 and Section 4 provide background on the Korean banking industry and describe the data used in this paper. In Section 5, I introduce the structural demand model and supply model and suggest the estimation method. Results, including network analysis, are presented in Section 6. Section 7 summarizes the paper and suggests future research.

2.2 Literature Review

Dick (2002) was the first to apply a structural demand model to the banking industry[4]. She estimates a demand model for commercial bank deposit services using both a logit model and a nested logit model. Based the logit and nested logit estimates, she finds the median of the price elasticities to be 5.9 and 10.9 respectively, with

[4]Recently, the empirical industrial organization economists have developed discrete choice demand models with applications to various differentiated products, such as automobiles, cereals, movies, and so on (Berry et al., 1995, Nevo, 2001, Davis, 2004).

implying that the nested logit model improves the estimates of the price elasticities. She also evaluates whether the deregulation of banks' geographic diversification is an appropriate policy in terms of consumer welfare. Adams et al. (2004) focus on the substitutability of depository institutions using a generalized extreme value framework[5]– thrifts and banks, single-market and multi-market institutions. They find significant market segmentations in both dimensions.

However, these papers do not exploit information such as cost variables in the supply side. My analysis builds on a discrete choice demand model in an equilibrium framework developed by Draganska and Jain (2005). Draganska and Jain (2005) explicitly model a firm's decision of product-line length as well as price in the yogurt market. They derive the supply equations from the price and line length decisions of the oligopoly firms and then estimate simultaneous equation model by combining them with a discrete choice demand model.

Grzelonska (2005) focuses on the effect of the geography of other branches in the network on the deposit amount of one bank branch. She finds that the convenience of a bank's branch network positively affects its deposit amounts. Kiser (2002) illustrates the importance of location on a consumer's choice of depository institution using data from the Michigan Surveys of Consumers. Cohen and Mazzeo (2005) model the branching decision of banks with allowing for the endogeneity of market structure and product differentiation. Knittel and Stango (2004) and Ishii (2004) examine the effect of the incompatibility of ATM networks[6] on the consumer welfare and investment in ATM networks, with focusing on the importance of the ATM network in the consumer's decision.

Cerasi et al. (2002) test the effect of deregulation on nine EEC banking

[5] They use a discrete choice model suggested by Bresnahan et al. (1997), which enables more flexible market segmentation testing than the nested logit model.

[6] Surcharging or interconnection pricing creates a partial incompatibility between banks' ATM networks by price discriminating between affiliated and unaffiliated consumers.

industries in the period from 1990 to 1996 by modelling the strategic aspects of branching activities. Their econometric test is derived by separating the effects of the toughness of price competition and branching cost on the branching activities. Pinho (2000) also examines the impact of deregulation on competition between banks in the Portugese banking industry. Pinho (2000) focuses on different responses in the non-price competition of old institutions and new small institutions in the deregulation process. He shows that the smaller institutions expanded advertising and branch activities much more than did the larger institutions. In contrast, this paper examines the effect of widely divergent branch networks on market power in the Korean banking industry during the deregulation period.

One of the main issues in the Korean banking industry – banks' changes in the technological systems during the deregulation process after 1980 – is reviewed by Gilbert and Wilson (1998). By using Malmquist indexes of productivity change, they found that Korean banks substantially changed their mix of inputs and outputs, making large enhancements in productivity during privatization and the deregulation period. This paper is complementary to Gilbert and Wilson (1998), in that it examines the competition between banks given the enhanced productivity after deregulation process.

2.3 The Korean Banking Industry

Until the end of the 1970s, only a few nationwide commercial banks competed under Korean government control[7]. The government control over the banking sector aimed mainly to support export-led economic growth. Government-owned specialized

[7] The nationwide banks are Cho-heung bank, Sang-up bank, Je-il bank, Han-il bank, and Seoul bank. Cho (1998) discusses the financial sector policies in the period from 1960s to 1980s and financial reforms in the 1990s.

banks[8] were established in the 1960s to support specific sectors. Privately-owned regional banks were also established in the late 1960s. These banks were allowed to locate their branches in their own provinces, but not outside those provinces[9].

Realizing the limit of its control over the financial sector at the end of 1970s, the Korean government started to lift many regulations controlling the management and operations of banks. The ownership of many nationwide commercial banks was released from the government hands by 1983. During this period, the Korean government began indirect control through the management of bank reserve requirements. The government also encouraged the establishment of new banks by lowering regulatory restrictions on entry into the market. Two new nationwide commercial banks, namely Shinhan Bank and Koram Bank, were established in 1982 and 1983, respectively. In addition, the Korea Exchange Bank converted to a nationwide commercial bank in 1989[10]. Three other new commercial banks (Dong-hwa bank, Dong-nam bank and Dae-dong bank) were established in 1989. Hana Bank and Boram bank were established in 1991 and Peace Bank in 1992. Deregulation of bank management and the establishment of many new banks characterized the Korean banking industry during 1980s and early 1990s.

In the early 1990s, the Korean government started to reform the financial system by lifting regulations on interest rates on deposits and loans. A 4-stage plan for interest rate deregulation was announced. In 1991, deregulation was applied only to deposits with maturities of at least three years under the first stage of the plan. The second stage, undertaken in 1993, lifted regulation on interest rates for

[8]e.g., Korea Development Bank, the National Agricultural/Fisheries Cooperatives Federation, the Industrial Bank of Korea, the Citizens National Bank, the Korea Exchange Bank, and Korea Housing Bank.

[9]The only exception was that they were able to locate branches in Seoul, although only one branch per bank was permitted.

[10]In 1995 and 1997, the Citizen National Bank and Korea Housing Bank also converted to nationwide commercial banks.

long-term deposits with maturities of two years or more. In 1994, the period of the third stage, deposit rates with maturities of at least one year were deregulated. In 1995, the government extended deregulation of deposit rates to all deposits except for demand deposits.

2.4 Data

2.4.1 Data Source

My data come from various sources. Annual data on all commercial banks[11] and demographics in each market are available for the years 1994-1996. The data include amount of each branch's deposits, number of employees, provision of foreign exchange, branch address, and its year of inception from year books published in the Korea Federation of Banks. I use each bank's deposit interest rates and loan interest rates and a bank-level cost variable such as expenditure-per-employees from the Bank Management Statistics published in the Financial Supervisory Service. I use market interest rates such as yields of CDs or yields of corporate bonds from the Bank of Korea. Data on the population, business, and market area size were obtained from the Korea National Statistical Office.

2.4.2 Bank characteristics

I model the depositor's choice problem in terms of which bank she chooses given the banks' characteristics in each market. I divide each bank's service into two dimensions – branch numbers (density) and average branch service in a market. The bank characteristics used to construct the explanatory variables that affect depositor utility include deposit interest rate, the number of bank branch offices in

[11] They include data on nationwide banks, regional banks, and government owned banks.

the market, the bank's age, the number of employees per branch, the percentage of bank branches serving foreign exchange, and the percentage of recently established bank branches.

The number of bank branches may affect depositors' utility positively by providing easier access to the bank. The Bank's age proxies for bank reputation, since depositors may think those banks are more secure. The number of employees per branch and the percentage of branches serving foreign exchange represent deposit associated service qualities the bank provides. Finally, I added the ratios of recently established branches to total branches as explanatory variables in the model, so that it could allow for disadvantages coming from costs incurred to the consumer from switching banks. It is likely that depositors may not change banks due to the costs of breaking the contract for their deposit.

2.4.3 Geographic Markets

I define 113 local geographic areas in each year as "markets"[12]. Smaller administrative districts in the metropolitan areas are defined as "markets". The 113 markets consist of 52 metropolitan areas and 61 local cities. With 3 years of panel data, I have 339 market observations.

Table B.2 and Table B.3 provide a brief summary of the markets for two categories of areas. Markets in the metropolitan area have around 0.4 million people and 51km^2 in area[13], while geographically separated local cities have average 0.2

[12]Rural areas and very small cities are omitted, since there are few branches in those areas. I omitted 5 small cities that have less than 30,000 population or 0.05 population per kilometer square, and I ruled out all rural areas. The deposit amounts in these markets, including rural areas, take on only less than 5% of the total market deposit amounts.

[13]Markets defined in the metropolitan area have a problem in that consumers who are near a boundary line are likely to choose a bank across the geographic market. Thus this market definition would be sensible based on the restrictive assumption that few depositors choose a bank across geographic markets. Although it may be problematic, the market definition having, on average, 0.4 million people and 51 km^2 in area is still a big market and probably does not give as much bias.

million people and 114km^2 in area. Markets vary in the number of competitors and their branch network. In 1996, markets in the metropolitan area had an average of 11 banks and 56 branches. Local cities had an average of 8 banks and 34 branches in the same year.

2.4.4 Market Shares

I obtain the total deposits held by each bank in each market during the sample period from the Korea Federation of Banks. The data include not only nationwide commercial banks and regional banks but also government-owned, specialized banks. I define the deposit amounts of each bank in the market over the sum of deposit amounts of all banks including government-owned banks in the market as the bank's "market share". I assume that depositors choose at least one bank and deposit their money. In particular, I define the government owned banks as "the outside good". Then, they choose either one bank (among nationwide banks and regional banks) or the government-owned banks[14]. This measure of market share is based on the assumption that depositors would save their money in one of various depository institutions.

Each bank's market share in various markets is based on the deposit amounts held by each bank. Deposits here include checking (deposit) account balances, savings, and other time deposits such as money markets and CDs. Thus, a market share is determined by shares of various products. Only total deposit amounts are available at each branch level. Given this data constraint, this measure might be problematic. Following the observation of the Survey of Consumer Finances that consumers are likely to acquire banking services together (Amel and Starr-McCluer,

[14] Knittel and Stango (2004) define market share as the ratio of deposit amounts held by each bank to the total deposit amounts of all banks including credit unions and they use credit unions' deposits to calculate the share of the outside good.

2001), a high correlation between products helps to mitigate significant measurement error.

2.5 The model

I formulate a discrete choice demand model that allows consumers to choose a bank for deposit services such as checking, savings, time deposit accounts, and money market funds. Banks are assumed to maximize profits by setting deposit interest rates and choosing their branch network. I will estimate demand and supply simultaneously in an equilibrium framework, as suggested by Berry et al. (1995).

Following Lancaster (1966), banks are defined by their characteristics and consumers are endowed with preferences for characteristics. The discrete choice logit model (McFadden (1973)) then builds aggregate demand from depositors' random utility for the characteristics of the products. The differentiated products demand model should be associated with demand estimation of the large number of products.

On the supply side, banks will be assumed to compete in deposit interest rates and branch network in a Bertrand-Nash fashion. By explicitly modelling the banks' choice of branch network, I will account for the interdependency between price and branch network decisions and evaluate the bank branch network as a competitive tool.

2.5.1 Consumer choice

Discrete choice demand models have been explored in differentiated product markets such as automobiles, cereal, movies, etc. Here, I follow the discrete choice methodology, the logit model and the nested logit model, to estimate deposit demand in the banking industry.

Consumers are interested in purchasing deposit services from a bank. Assume that $m = 1, 2, ...M$ markets are observed in each period $t = 1, 2, ...T$, each with $i = 1, 2, ...I_{tm}$ depositors and $j = 1, 2, ...J_{tm}$ firms. The utility consumer i derives from a bank j at the market m at time t is given by

$$\begin{aligned} U_{ijtm} &= U(\varepsilon_{ijtm}, r^d_{jt}, x_{jtm}, br_{jtm}, \xi_{jt}; \theta_d) \\ &= \mu_{ijtm} + \varepsilon_{ijtm} = x_{jtm}\beta^i + \alpha^i r^d_{jt} + f^i(br_{jtm}) + \xi_{jtm} + \varepsilon_{ijtm} \end{aligned} \tag{2.1}$$

where ε_{ijtm} is a mean zero random disturbance and $\mu_{ijtm}(= x_{jtm}\beta^i + \alpha^i r^d_{jt} + f^i(br_{jtm}) + \xi_{jtm})$ is the mean utility of consumer i. r^d_{jt} represents deposit interest rate paid by bank j, $f^i(br_{jmt})$ represents consumer preference over the accessibility to the bank, x_{jtm} is a K-dimensional row vector of the observed characteristics of the bank j in a market tm, and ξ_{jtm} represents the bank j's specific unobserved characteristics in the market. I assume that observed bank characteristics are independent of unobserved bank characteristics[15]. I assume that consumer i's utility for the outside goods is given by $U_{i0mt} = \varepsilon_{i0mt}$. Assuming a uniform distribution of bank offices and bank customers, there is an inverse relationship between distance travelled and the number of banking facilities per square mile. Thus, accessibility can be measured as the number of banking facilities per square mile.

A Preference over the Access to a Bank: I assume that consumers have a preference for accessibility of a bank[16]. Then, the contribution of bank j's

[15] Price variables (deposit interest rates) and branch density are assumed to correlated with the bank's unobserved characteristics in the market and thus instrument variables are needed.

[16] Kiser (2002) reports the importance of location in the consumer choice of depository institution from the Michigan Surveys of Consumers. Following Evanoff (1988), I take the number of banking facilities per square mile for a measure of the access to bank. "...Ideally, a measure of service accessibility would incorporate the characteristics of time, distance, and cost incurred in obtaining financial services. Absent a direct measure of time and cost, some gauge of average distance travelled would be an appropriate proxy." Evanoff (1988).

branches to the consumer i's expected utility is assumed to be given by

$$f^i(br_{jmt}) = \phi_1^i \times \frac{br_{jmt}}{\text{market area size}} + \phi_2^i \times \left\{\frac{br_{jmt}}{\text{market area size}}\right\}^2, \tag{2.2}$$

where ϕ_1^i and ϕ_2^i represent the magnitudes of the consumer i's marginal utility for the increase in the branch density. By adding the square of branch density, I allow for either concave or convex consumer utility for branch network.

Market Shares: Each consumer i chooses the bank j that maximizes her utility, so that she chooses it whenever $U(\varepsilon_{ijtm}, \tau_{jtm}; \theta_d) \geqq U(\varepsilon_{iktm}, \tau_{ktm}; \theta_d)$, for $k = 0, 1, ..., J$ and $k \neq j$, where $\tau_{ktm} = (r_{kt}^d, x_{ktm}, br_{ktm}, \xi_{ktm})$ denotes the bank j's observed and unobserved characteristics and $k = 0$ represents the outside alternative. The distribution of consumer characteristics is assumed to be known. The set of consumers that choose the bank j at time t in a market m is

$$A_{jtm} = \{\varepsilon_{ijtm} : U(\varepsilon_{ijtm}, \tau_{jtm}; \theta_d) \geqq U(\varepsilon_{iktm}, \tau_{ktm}; \theta_d) \text{ for } k = 0, 1, ..., J_{tm}, k \neq j\}. \tag{2.3}$$

The market share of bank j is thus obtained by integrating out the set of consumers choosing the bank j over the distribution. Given a density $f(\epsilon)$ for ϵ, the market share of bank j under the logit or nested logit assumption is

$$s_{jtm}(\tau_{jtm}; \theta_d) = \int_{\epsilon \in A_{jtm}} f(\bar{\epsilon}) d\bar{\epsilon}. \tag{2.4}$$

Given the market share, demand for bank j at time t in a market m is defined as a multiplication of market size and market share, $M_{tm} s_{jtm}(\tau_{jtm}; \theta_d)$. Total demand for bank j at time t is obtained by summing its demand across all markets, $\sum_m M_{tm} s_{jtm}(\tau_{jtm}; \theta_d)$.

A Logit Model: A simplifying yet restrictive assumption regarding consumer heterogeneity is that the random error ε_{ij} is i.i.d. extreme value with the distribution function $\exp(-\exp(-\epsilon))$, and it enters utility only through an additive-separable form[17]. It also assumes no random coefficients, $\theta^i = \theta$. By integrating the individual utilities over random disturbances, ε, the market shares of bank j and outside goods are respectively

$$s_j(\mu;\theta_d) = \frac{\exp(\mu_j)}{\sum_{k=0}^{J_{tm}} \exp(\mu_k)} \tag{2.5}$$

$$s_0(\mu;\theta_d) = \frac{1}{\sum_{k=0}^{J_{tm}} \exp(\mu_k)}. \tag{2.6}$$

For outside goods, the mean utility of the outside good is normalized to zero, $U_{i0mt} = \varepsilon_{i0mt}$. Taking logs of market shares, the following structural linear equation,

$$\ln(s_j) - \ln(s_0) = \mu_j - \mu_0 \equiv x_j\beta + \alpha r_j^d + f(br_j) + \xi_j, \tag{2.7}$$

is obtained. In this model, the derivatives of market share with respect to deposit interest rate are

$$\frac{\partial s_j}{\partial r_j^d} = \alpha s_j(1 - s_j) \tag{2.8}$$

$$\frac{\partial s_k}{\partial r_j^d} = \alpha s_j s_k. \tag{2.9}$$

The logit model assumes homogeneous tastes for observable characteristics, hence restricting different consumers to have only different i.i.d. shock. As stressed in the literature, the i.i.d. structure of the random shock is problematic for the cross-price elasticities. The increase in the deposit interest rate of a bank j probably makes some depositors who had previously chosen it move to other banks. Due to

[17] I have dropped subscripts indicating observations, such as t and m, when explaining the logit and nested logit model.

the i.i.d. structure of random utility, the number of depositors who will move to other banks is proportional to the market share of those banks, regardless of their characteristics. It would be logical to assume that depositors move to banks that have similar characteristics to bank j.

A Nested Logit Model: In contrast to the simple logit model, the nested logit model still assumes the extreme value distribution but allows consumer tastes to be correlated across similar products. Given the group of the products in G+1 exhaustive and mutually exclusive sets, ϱ_g, $g = 0, 1, 2, ..., G$, the utility of depositor i is assumed to be $U_{ij} = \mu_j + \zeta_{ig} + (1-\sigma)\varepsilon_{ij}$, where $\mu_j \equiv x_j\beta + \alpha r_j^d + f(br_j) + \xi_j$ and ε_{ij} is i.i.d. extreme value. For consumer i, the variable ζ_{ig} is a random variable common to all products in group g. According to Cardell, $\zeta_{ig} + (1-\sigma)\varepsilon_{ij}$ also has an extreme value distribution under some regularity conditions. The market share of the product j can be divided into the share of product $j(\in \varrho_g)$, conditional on the choice of the group g and the group g's share. Referring to Berry (1994), the market share of the product j is given by

$$s_j(\mu;\sigma,\theta_d) = s_{j|g}(\mu;\sigma,\theta_d)\overline{s_g}(\mu;\sigma,\theta_d) = \frac{\exp(\mu_j/(1-\sigma))}{D_g}\frac{D_g^{1-\sigma}}{\sum_g D_g^{(1-\sigma)}}, \tag{2.10}$$

where $D_g \equiv \sum\limits_{j\in\varrho_g} \exp(\mu_j/(1-\sigma))$. With $\mu_0 \equiv 0$ and $D_0 = 1$ for the outside good, $s_0(\mu_j;\sigma,\theta_d) = \frac{1}{\sum_g D_g^{(1-\sigma)}}$. Taking logs of market shares,

$$\ln(s_j) - \ln(s_0) = \mu_j/(1-\sigma) - \sigma\ln(D_g). \tag{2.11}$$

Taking the log of the group share, $\ln(D_g) = (\ln(\overline{s_g}) - \ln(s_0))/(1-\sigma)$, where $\overline{s_g}$ represents the observed group share. Substituting this into the equation (11) and combining terms give

$$\ln(s_j) - \ln(s_0) = x_j\beta + \alpha r_j^d + f(br_j) + \sigma \ln(s_{j|g}) + \xi_j, \tag{2.12}$$

where $s_{j|g}(= s_j/\overline{s_g})$ is the market share of product j as a fraction of the total group share. As the estimated parameter σ $(0 \leqq \sigma < 1)$ approaches one, the within group correlation goes to one. It implies that when price goes up, consumers who have chosen a product j in a group would probably change to another product in the same group rather than change to one in to another groups. Since the last term in the left side $\overline{s}_{j|g}$ is endogenous, it requires additional exogenous variables that are correlated with the within group share. As suggested in the literature, the characteristics of other banks in the group will be taken as instrument variables. In this model, the derivatives of market shares with respect to deposit interest rate are

$$\frac{\partial s_j}{\partial r_j^d} = \frac{\alpha}{(1-\sigma)} s_j[1 - \sigma\overline{s}_{j|g} - (1-\sigma)s_j] \tag{2.13}$$

$$\frac{\partial s_k}{\partial r_j^d} = \frac{\alpha}{(1-\sigma)} s_j[\sigma\overline{s}_{k|g} + (1-\sigma)s_k], \text{ where } k, j \in \varrho_g \tag{2.14}$$

$$\frac{\partial s_k}{\partial r_j^d} = \frac{\alpha}{(1-\sigma)} s_j[(1-\sigma)s_k], \text{ where } k \notin \varrho_g, \ j \in \varrho_g. \tag{2.15}$$

2.5.2 Bank's branching and pricing strategies

Banks are assumed to compete in prices and branch network in a Bertrand-Nash fashion. I assume that the banks have a uniform pricing policy across locally geographic markets in each period. r_{jt}^l denotes bank j's loan interest rate[18]. In each period t bank j determines the branch network and deposit interest rates to maxi-

[18] Alternatively, following Pinho (2000), bank j's profit function is $\Pi_{jt} = \sum_m \{M_{tm}s_{jtm}(r_t^s - \rho - r_{jt}^d - mc_{jt}) - g_{jtm}(br_{jtm})\}$, where r_t^s denotes the market interest rates (e.g. yields of CDs) in period t and ρ denotes the cash reserve rate, usually 5% - 10%. Results from a market interest rate are very similar to those from banks' loan interest rates.

mize profits:

$$\max_{\{r^d_{jt}, br_{jtm}\}} \Pi_{jt} = \sum_m \{M_{tm} s_{jtm} (r^l_{jt} - r^d_{jt} - mc_{jt}) - g_{jtm}(br_{jtm})\}, \tag{2.16}$$

where mc_{jt} denotes the bank j's marginal cost of providing deposit service and $g_{jtm}(br_{jtm})$ represents the bank j's cost function of branching activity.

The first order condition for the deposit interest rate set by bank j is given by

$$\frac{\partial \Pi_{jt}}{\partial r^d_{jt}} = -\sum_m M_{tm} s_{jtm} + \sum_m M_{tm} \frac{\partial s_{jtm}}{\partial r^d_{jt}} (r^l_{jt} - r^d_{jt} - mc_{jt}) = 0. \tag{2.17}$$

The marginal cost consists of the cost shifters such as wages or factor prices, ϖ_{jt}, and unobserved shocks to marginal cost, η_{jt}: $mc_{jt} = \varpi'_{jt}\gamma_j + \eta_{jt}$. It is assumed that η_{jt} is constant across markets for a given bank and independent of ε_{ijtm}. However, it may be expected that any unobserved bank characteristics ξ_{jtm} that influence depositor decisions might also affect the unobserved cost component, η_{jt}. With the marginal cost specification and $\frac{\partial s_{jtm}}{\partial r^d_{jt}} = \alpha s_{jtm}(1 - s_{jtm})$, the first order condition of the deposit interest rate becomes the estimating equation as follows:

$$r^l_t - r^d_{jt} = \varpi'_{jt}\gamma_j + \frac{\sum_m M_{tm} s_{jtm}}{\alpha \sum_m M_{tm} s_{jtm}(1 - s_{jtm})} + \eta_{jt}. \tag{2.18}$$

The first order condition for branch network choice of bank j is given by

$$\frac{\partial \Pi_{jt}}{\partial br_{jtm}} = M_{tm} \frac{\partial s_{jtm}}{\partial br_{jtm}} (r^l_{jt} - r^d_{jt} - mc_{jt}) - g'_{jtm}(br_{jtm}) = 0. \tag{2.19}$$

I also assume that $g'_{jtm}(br_{jtm}) = \delta_{j1} + \delta_{tm2} + \delta_{j3} br_{jtm} + \nu_{jtm}$ and ν_{jtm} are random fluctuations in the marginal costs of forming a branch network. The first term in the right side is the marginal benefit from having a branch network, which can be divided into the market demand response from increasing the branch network and the price cost markup. The marginal cost is assumed to vary across banks and markets. I assume that it is linear in the number of branches so that the cost of having branch network would have a quadratic function, be it convex or concave. The unobserved bank characteristics ξ_{jtm} might be correlated with an unobserved cost component, ν_{jtm}. Combining the equations (2.17), (2.19) and $\frac{\partial s_{jtm}}{\partial br_{jtm}} = f'(br_{jtm})s_{jtm}(1 - s_{jtm})$, the estimating equation for the branch network is given by

$$0 = \frac{f'(br_{jtm})M_{tm}s_{jtm}(1 - s_{jtm})\sum_m M_{tm}s_{jtm}}{\alpha \sum_m M_{tm}s_{jtm}(1 - s_{jtm})} - \delta_{j1} - \delta_{tm2} - \delta_{j3}br_{jtm} + \nu_{jtm}. \quad (2.20)$$

2.5.3 Estimation Issues

Estimation method

I use the generalized method of moments (GMM) procedure to estimate the system of supply and demand equations. I follow a moment approach (Berry et al, 1995, suggested) using the instruments for both demand and supply equations as observed product characteristics (except deposit interest rates and branch density), X_{jtm}, and cost shifters, W_{jtm}. The maintained assumption is that at the population parameter values, θ_0, the supply and demand unobservables $[\xi_{jtm}(\theta_0), \eta_{jt}(\theta_0), \nu_{jtm}(\theta_0)]$ have zero means conditional on the instrument variables, $Z_{jtm} = [X_{jtm}, W_{jtm}]$, which is given by

$$E[\xi_{jtm}(\theta_0)|Z_{jtm}] = E[\eta_{jt}(\theta_0)|Z_{jtm}] = E[\nu_{jtm}(\theta_0)|Z_{jtm}] = 0. \quad (2.21)$$

Let $\omega_{jtm}(\theta) = [\xi_{jtm}(\theta)', \eta_{jt}(\theta)', \nu_{jtm}(\theta)']'$ be a 3×1 matrix with the unobserved bank characteristics and the shock for marginal costs in each market tm and $\omega_j = [\omega_{j11}^{'}, ...\omega_{jtm}^{'}, ..., \omega_{jTM}^{'}]'$ be $3(2M + 1)T \times 1$ matrix[19]. Let $Z_j =$

[19]For a bank j, both ξ_{jtm} and ν_{jtm} vary across markets and years with TM observations, but η_{jt} varies only across years with T observations.

$[Z'_{j11}, ...Z'_{jtm}, ..., Z'_{jTM}]'$ be $3(2M+1)T \times K$ matrix of instrument variables for j bank's equations. Then, I can construct orthogonality conditions, $Z_j'\omega_j(\theta)$, using the instrument covariates, Z_j, that are mean independent of $\omega_j(\theta)$. $\omega(\theta)$ and Z are given by

$$\omega(\theta) = \begin{bmatrix} \omega_1(\theta) \\ \omega_2(\theta) \\ : \\ : \\ \omega_J(\theta) \end{bmatrix} \quad \text{and} \quad Z = \begin{bmatrix} Z_1 & 0 & & 0 \\ 0 & Z_2 & & 0 \\ . & & . & . \\ . & & . & . \\ 0 & 0 & . \; . & Z_J \end{bmatrix}. \tag{2.22}$$

Let $Z'\omega(\theta)$ be the stacked vector of moment conditions for the whole system. Then, $G(\theta) = Z'\omega(\theta)$ will be the set of moments that enter the GMM objective function, while assuming the population moment conditions, $E[G(\theta_0)] = 0$. The GMM estimator solves for the θ that sets these moments as close to zero as possible. I use a two-step optimal weighted GMM. In the first stage, I use an identity matrix as a weight matrix to obtain a consistent estimate, $\widehat{\theta}^1$. Then the estimated parameters in the second stage solve

$$\widehat{\theta} = \arg\min_{\theta} \omega(\theta)' Z \widehat{\Sigma}^{-1} Z' \omega(\theta), \tag{2.23}$$

where $\widehat{\Sigma} = \widehat{var}(Z'\omega(\widehat{\theta}^1))$[20]. $\widehat{\theta}$ has an asymptotical normal distribution with variance-covariance matrix

$$(\Gamma' A \Gamma)^{-1} \Gamma' A V A \Gamma (\Gamma' A \Gamma)^{-1}, \tag{2.24}$$

where $\Gamma = \frac{\partial G(\theta_0)}{\partial \theta}$ and $V = E[Z'\omega(\theta)\omega(\theta)'Z]$.

[20]The optimal weighting matrix is given by the inverse of the expected variance-covariance matrix of the orthogonality conditions, denoted $\Sigma = var(Z'\omega)$.

Instrument variables

Instrument variables are required for deposit interest rates, branch density, and within group share for the nested logit model[21]. Following Berry et al. (1995), I use sum of other observed characteristics of rival banks. While competitors' characteristics are exogenous from one bank's perspective (ξ_{jtm}), they are correlated with the bank's deposit interest rate in that they are associated with the substitutability of the bank. I use sums of observed characteristics in the group as the instrument variables for the within group share, which Bresnahan et al. (1997) suggested with similar arguments as above. I use one year lagged branch density as instrument variables for branch density, since it is likely to be correlated with the costs of forming the current branch network.

2.6 The Results

2.6.1 Basic Analysis

Table B.4 shows the estimation results of demand parameters using the GMM method. Estimates in the first two columns result from the IV logit assumption, while those in the last two columns come from the nested logit assumption. The signs of all parameters in both models are the same as expected. Depositor utility for branch density is concave, meaning that they derive less marginal utility when branch density increases. Proxies for service quality per branch, such as the average logarithm of employees per branch and the branch portion of serving foreign exchange, have positive signs. The coefficient of the logarithm of bank age is also positive. It is likely that when they switch banks, depositors might pay a penalty for breaking their established deposit contract. As explanatory variables for this switch-

[21]These variables are endogenous in that they are likely correlated with unobserved bank characteristics ξ_{jtm}.

ing cost, I added the portions of recently established branches, such as one-year-old branches, two-years-old branches, and three-years-old branches, to the regression. There is a notable disadvantage for recently established branches due to depositors' switching costs.

Two important coefficients in Table B.4 need to be explained. First, demand models eventually focus on the magnitude of consumers' responses to price, typically price elasticity of demand. As defined in equation 1, $\frac{\partial s_j}{\partial r_j^d} = \alpha s_j(1-s_j)$, the derivative of bank j's market share with respect to its deposit interest rate is reflected in the magnitude of the estimated coefficient of price, $\widehat{\alpha} = 0.474$ for the IV logit model.

The nested logit model enables us to test market segmentation between grouped products. As explained in the previous section, σ in the nested logit model represents within group correlation of consumer tastes. Thus, as σ gets larger, depositors are more likely to switch within grouped banks than to switch between grouped banks. For instance, when the estimated σ equals 1, it means that if a depositor changes her bank, she would switch only to another bank in the group that the bank belongs to. In this case, markets across the grouped products are interpreted to be fully segmented. I assumed two bank groups: "inside goods" (e.g., commercial banks) and "outside goods" (e.g., government-owned specialized banks). $\widehat{\sigma} = 0.62$ can be interpreted to mean that the market is very segmented between commercial banks and government-owned specialized banks[22].

The estimated derivatives of bank j's market share with respect to its deposit interest rate are derived from the estimated coefficients of price in the logit model and the nested logit model, respectively. For instance, let bank j have $\overline{s}_{j|g} = 0.12$ and $s_j = 0.05$. Given $\widehat{\alpha}_{|Logit} = 0.474$ and $\widehat{\alpha}_{|Nested} = 0.197$ with $\widehat{\sigma} = 0.616$, the

[22]From the equation 3, $\frac{\partial s_j}{\partial r_j^d} = \frac{\alpha}{(1-\sigma)} s_j[1 - \sigma \overline{s}_{j|g} - (1-\sigma)s_j]$, as σ is larger, the ratio of market share to the group share, $\overline{s}_{j|g}(= s_j/\overline{s}_g)$, is much weighted for measuring the depositors' demand sensitivity.

derivatives of bank j's market share with respect to its deposit interest rate are $\frac{\partial s_j}{\partial r_j^d}|_{Logit} = 0.0229$ and $\frac{\partial s_j}{\partial r_j^d}|_{Nested} = 0.0232$. Note that although the estimated coefficient of price are smaller in the nested model, the estimated derivatives of bank j's market share are a little greater in the nested model.

Results in Table B.5 show the coefficients of marginal costs estimated in the equilibrium model combining demand and supply. Marginal costs due to the deposit interest rate increase are assumed to be constant across banks. The estimate of marginal cost are 0.897 in the logit model and 0.863 in the nested logit model. The estimate of marginal cost of branching activities increases with the number of branches, implying a convex cost function of the number of branches. As a bank's age increases, the marginal cost of branching activities decreases. It might be due to a high fixed cost investment and regulation on branching activities per year. Regional banks' branching activities only in the restrictive provinces may cost less than it does for other banks branching extensively throughout the nation.

2.6.2 Network Analysis

Commercial banks in Korea can be divided into three categories, which differ in the branch network. The first one – the big 6 nationwide commercial banks that entered before 1960s – has an 'extensive' branch network[23] with 300-400 branches (lots of branches) throughout the nation. The second one – the medium-sized nationwide commercial banks that entered the market after 1980s – has an 'extensive' branch network with around 100 branches (small number of branches) throughout the nation. The third one – the regional banks restricted to their provinces – has an 'intensive' branch network with around 100 branches in their regions.

[23] Banks may locate their branches in many markets but small number of branches in the market, or they may locate their branches in small number of markets but many branches in the market. I call the former branch network "extensive branch network" and the latter branch network "intensive branch network".

Table B.6 and Table B.7 show summary statistics for branch networks for the three categories of banks over the sample period (1994-1996). Figure B.1 also shows the trend of branch networks and deposit interest rates for the three categories of banks. Like branch networks, deposit interest rates also are relatively similar among banks in the each category. In particular, note that although medium-sized banks and regional banks, on average, have around 100 branches, those two categories of banks are very different in deposit interest rates. Based on these three categories of banks, I analyze the effects of branch network on markups, own / cross price elasticity of demand, the branch elasticity of demand, and depositor's preference over branch density and deposit rate.

Estimated markups and price elasticity of demand

Table B.10 shows the estimated markups, which are average values within the three categories of banks for each period. The estimated markup defined as price minus the estimated marginal costs can be obtained in the model assuming Bertrand-Nash competition as follows; $r_t^l - r_{jt}^d - \widehat{mc}_{jt} = \frac{\sum_m M_{tm} s_{jtm}}{\widehat{\alpha} \sum_m M_{tm} s_{jtm}(1-s_{jtm})}$. Regional banks have the highest markups, 2.80%-2.85%. Big 6 banks have markups of 2.3% and medium-sized banks have markups of 2.2%. Banks' estimated markups amount to about 25%-40% of their deposit interest rates. Although big 6 banks have around 3 times more branches than regional banks, the estimated markups of regional banks are much greater than those of big 6 banks. It is regarded that the intensive branch networks, for instance those of regional banks, are used to increase markups more effectively.

Banks expanded their branches competitively, as evidenced by the more than 10% annual growth rate of bank branches from 1994 to 1996. However, this branching competition did not increase their markups as shown in Table B.10. Nationwide banks had relatively constant markups over the period and regional banks had slightly lower markups as well. Those banks' branch expansion competition may have two effects on their competitiveness. The first one increases depositors' willingness to pay by providing higher quality of service such as easy access to the bank and thus raises bank's competitiveness, which may increase deposit interest rates. The second effect increases depositors' willingness to pay for rivals' service due to rivals' branch expansion and thus reduces bank's competitiveness, which may decrease deposit interest rates. Based on the estimates, neither effect of branch expansion competition dominates.

Price elasticity of demand is the unit-free measure for depositors' responsiveness to price. It here is defined as $\frac{\partial Q_{jt}(r_{jt}^d)}{\partial r_{jt}^d}\frac{r_{jt}^d}{Q_{jt}(r_{jt}^d)} = \sum_m M_{tm}\frac{\partial s_{jtm}}{\partial r_{jt}^d} \times \frac{r_{jt}^d}{\sum_m M_{tm}s_{jtm}}$, based on the markets where the banks serve[24]. It can vary across firms in the same industry. Medium-sized banks have the highest price elasticity of demand, 3.77-4.03, while regional banks have the lowest elasticity of demand, 2.56-2.72[25]. It suggests that demand for medium-sized banks with small number of branches in the markets they serve are the most price sensitive and demand for regional banks with lots of branches in the markets they serve are the least price sensitive[26].

A measurement index for market power, the Lerner index, is defined as the inverse of price elasticity of demand. Using the Lerner index as the measurement of market power, the result in Table B.12 shows that regional banks have the highest Lerner index, $\frac{1}{2.56}(= 0.391)$. Big 6 banks and medium-sized banks have $\frac{1}{3.26}(= 0.307)$ and $\frac{1}{3.91}(= 0.256)$, respectively. That is, Regional banks with locally intensive

[24]The reason that it is formulated this way is that banks compete on uniform pricing across the markets it serves through its branch network.

[25]These estimated price elasticities of demand are consistent with the optimal pricing in the oligopoly model which should have a price elasticity of demand that is greater than one.

[26]Intuitively, suppose that there are only branches that a bank owns in a market. Then, the decrease in the bank's deposit interest rate would rarely reduce its demand in the market, implying a very low price elasticity.

branch networks have the highest market power. It is notable that big 6 banks have a higher Lerner index than the medium-sized banks. Therefore, It can be concluded that a bank's market power (Lerner index) is affected critically by its own branch network.

Table B.8 shows that the total market share of the big 6 banks and the 8 medium-sized banks was about 40% and 16%, respectively, while those of the 10 regional banks was only about 10%. According to Table B.9, on average, nationwide banks have higher deposit amount per branch than regional banks. It is regarded that the extensive branch networks, for instance those of nationwide banks, are used to attract depositors more effectively. This suggests that regional banks with market intensive branch network earn their profits by obtaining higher markups, while nationwide banks with market extensive branch network earn their profits by obtaining higher demand per branch.

Estimated cross price elasticity of demand

The analysis on the cross price elasticity of demand also is based on the multiple markets where banks serve. Cross price elasticity of demand is defined as $\frac{\partial Q_{kt}(r^d_{jt})}{\partial r^d_{jt}} \frac{r^d_{jt}}{Q_{kt}(r^d_{jt})} = \sum_m M_{tm} \frac{\partial s_{ktm}}{\partial r^d_{jt}} \times \frac{r^d_{jt}}{\sum_m M_{tm} s_{ktm}}$. Table B.14 shows the average cross price elasticity of demand based on three categories of banks. When a big 6 bank increases its deposit interest rate by 1%, another big 6 bank experiences a decrease in demand of, on average, 0.24%-0.26% and a medium-sized bank and regional bank experience a decrease in demand of, respectively, 0.23%-0.25% and 0.16%-0.17%. Regional banks experience less of decrease in demand than medium-sized banks and other big 6 banks, because the branch networks of the regional banks do not overlap much with those of other banks. It is noted that the cross price elasticity of demand does not vary over time, which might be ascribed to their balanced branch network growth over time.

The model shows that for a 1% increase in the deposit interest rate of a medium-sized bank, on average, a big 6 bank experiences a decrease in demand of 0.091%-0.103%, whereas a medium-sized bank experiences a demand decrease of 0.104%-0.113%, and a regional bank experiences a demand decrease of 0.039%-0.061%. It is notable that average cross price elasticity of demand of a medium-sized bank with another medium-sized bank is higher than with other categories of banks, in particular big 6 banks, despite the big 6 banks' most extensive branch network. This results from the fact that the branch networks of the medium-sized banks are likely to overlap with those of other medium-sized banks more than with those of the big 6 banks, with implying that medium-sized banks have targeted similar markets.

The estimated cross price elasticity of demand for deposit interest rate change in the regional banks is much smaller. Big 6 banks and medium-sized banks experience a decrease in demand of only 0.020%-0.024% and other regional banks experience a loss of 0.003%. These results indicate that cross price elasticity of demand is determined mostly by the degree of overlap between bank branch networks.

Estimated bank branch elasticity and depositor's indifference curve

Based on the estimates in the Logit model, Figure B.6 shows the average branch densities across markets on the vertical axis and the estimated median branch elasticity in the corresponding market on the horizontal axis. Figure B.6 shows a positive relation between branch density and branch elasticity. The result indicates that banks established their branches more in markets with higher branch elasticities that are more demand-sensitive to branching activities, for instance in markets in the metropolitan area.

Median branch densities across each category of banks (big 6 banks, medium-sized banks, and regional banks) in their markets served are presented in Figure B.7, with their corresponding branch elasticities. As shown in Figure B.7, regional banks have a higher branch density than other categories of banks, given the same branch elasticity. The equation (2.19) representing the optimal branch decision of banks can be transformed to $\frac{br^*}{Q} = \frac{(r^l - r^d - mc)}{g'(br)} \times \varepsilon_{br}$. Lower marginal costs of branching activity ($g'(br)$), higher markups ($r^l - r^d - mc$) and higher branch elasticity (ε_{br}) induce higher branch density. In particular, it is regarded that regional banks' higher branch density is ascribed to lower cost[27] and higher markup.

The estimated indifference curve in Figure B.8 represents depositors' preferences over different product characteristics, deposit interest rates and branch density. A concave preference over branch density may give an explanation for nationwide banks' extensive branch network making their branches higher average deposit amount. Also, given the concavity for branch density, banks' location of their new branches in markets with lower branch density may attract depositors more, for instance in cities or suburban areas rather than in a metropolitan area. The estimates representing concave preference for branch density are consistent with the higher growth rate of branch network in the regional cities than in metropolitan areas. According to Table B.3, the average number of branches in the cities increased from 25.4 to 34 in regional cities and from 50 to 56.1 in metropolitan areas over the sample period.

[27]The regional banks' lower marginal costs of branch activity may result from the lower opportunity cost. Due to the restrictions on location of their branches, regional banks may establish branches even in less profitable markets than outside their provinces. Therefore, the restriction lowers the opportunity cost of their branches.

2.7 Conclusion

This paper has developed a structural model in the competitive framework to examine banks' competition through their branch network and deposit interest rates. In particular, it explicitly modelled the banks' choice of deposit interest rates and branch network as well as the depositors' choice of banks. With focusing on competition among three categories of banks – big 6 banks, medium-sized banks, and regional banks, it examined the effect of banks' branch network and branch competition in the sample period (1994-1996). It also investigated the strategic relationship between deposit interest rate and branch network through the estimated markups, price / branch elasticity of demand and cross elasticity of demand.

The results indicate that all coefficients of deposit services, such as branch density, staffing, banks' age, and service of foreign exchange, are positive. The estimated price coefficient in the logit model is 0.4740, with price elasticity of demand 2.5-4.0 across the three categories of banks. Based on the logit results, the estimated markups for each category of banks vary from 2.2% (medium-sized banks) and 2.3% (big 6 banks) to 2.8% (regional banks), on average. The estimated price elasticity of demand is the smallest for regional banks, while it is the largest for medium-sized banks. This suggests that the banks' divergent branch networks have a significant effect on the estimated markups and the estimated price elasticities. In particular, regional banks with market intensive branch network earn their profits by obtaining higher markups, while nationwide banks with market extensive branch network earn their profits by obtaining higher demand per branch. The estimated markups of the three categories of banks were stable over the period (1994-1996), despite severe branching competition.

The estimated cross price elasticity of demand is the largest for big 6 banks with the most extensive branch network, which would be the most likely to overlap other banks' branches. It is the smallest for regional banks with the most intensive branch network, which would be the least likely to overlap other banks' branches. It suggests that substitutability among banks (cross price elasticities of demand) are related to the degree of overlap between their branch networks.

I found that the relationship between their branches and their branch elasticities in the markets is positive. Regional banks' higher branch density is ascribed to lower cost of branches and higher markup. The estimated concave preference over branch density is consistent with nationwide banks' extensive branch network and higher average deposit amounts of their branches.

This paper found that commercial banks expanding their branches in the sample periods did not change their market power or markups. Seemingly, the banks' branch expansion succeeded in increasing their deposit amounts. However, the branch competition between banks caused them to have almost the same market shares as before the branch competition. As a result, bank branch competition did not improve their profitability in the deposit market. After currency crisis, the government encouraged mergers between banks. 12 mergers between banks took place only in a short period of a few years. It would be worth of examining the effect of those mergers on the banks' market power.

Appendix A

Appendix of Chapter 1

A.1 Proofs

Proof of Lemma 1. Suppose $p^i_{bu} - p^i_{ec} > V_b$. Then, since $w + V_\theta - z_\theta f - p^i_{bu} < w - z_\theta f - p^i_{ec}$ for all $(f, \theta(= b \text{ or } t))$, any traveller choosing between airline i's two classes will purchase airline i's economy class service. However, if airline i reduces p^i_{bu} to $\widehat{p^i_{bu}} = p^i_{ec} + V_b$, then any business travellers who would buy its economy class will change to business class. Such a price change reduces the cost by $V_b - c_H$ for each of airline i's business travellers, while it does not cause airline i to lose demand from business travellers. Hence, it contradicts.

Suppose $p^i_{bu} - p^i_{ec} < V_t$. Then, since $w + V_\theta - z_\theta f_\theta - p^i_{bu} > w - z_\theta f_\theta - p^i_{ec}$, for all (f, θ), any traveller choosing between airline i's two classes will purchase airline i's business class. However, if airline i reduces p^i_{ec} to $\widehat{p^i_{ec}} = p^i_{bu} - V_t$, then any tourists who would buy business class will change to economy class. Such a price change should reduce costs by $c_H - V_t$, without making airline i lose demand from tourists. Hence, it contradicts. ■

Proof of Lemma 2. By Lemma 1, each airline i's profit maximization problem is

$$\max_{\{p^i_{bu},\, p^i_{ec}\}} \pi^i = \frac{N}{1+\beta}\{\beta(\frac{z_b + p^j_{bu} - p^i_{bu}}{2z_b})(p^i_{bu} - c - c_H) + (\frac{z_t + p^j_{ec} - p^i_{ec}}{2z_t})(p^i_{ec} - c)\} \tag{A.1}$$

, where $i = A, B$ and $j \neq i$.

From FOCs,

$$p^i_{bu}(p^j_{bu}, p^j_{ec}) - p^i_{ec}(p^j_{bu}, p^j_{ec}) = \frac{1}{2}\left(p^j_{bu} - p^j_{ec} + c_H + z_b - z_t\right) \tag{A.2}$$

and

$$p^j_{bu}(p^i_{bu}, p^i_{ec}) - p^j_{ec}(p^i_{bu}, p^i_{ec}) = \frac{1}{2}\left(p^i_{bu} - p^i_{ec} + c_H + z_b - z_t\right). \tag{A.3}$$

Let $p^i_{bu} - p^i_{ec} = V_b - \delta$ $(V_b - V_t > \delta > 0)$. Substituting it into (3) and then (3) into (2) again, $p^j_{bu} - p^j_{ec} = \frac{1}{2}(V_b - \delta + c_H + z_b - z_t)$ and $p^i_{bu} - p^i_{ec} = \frac{1}{2}\{\frac{1}{2}(V_b - \delta + c_H + z_b - z_t) + c_H + z_b - z_t\} = \frac{1}{4}V_b + \frac{3}{4}(c_H + z_b - z_t) - \frac{1}{4}\delta > V_b - \delta$, since $z_b - z_t > V_b - c_H$. It contradicts. Thus, there is no equilibrium in which $V_b > p^i_{bu} - p^i_{ec} > V_t$ for some i. Suppose $p^i_{bu} - p^i_{ec} = V_t$. Then, by (3) and Lemma 1, $p^j_{bu} - p^j_{ec} = \min\{V_b, \frac{1}{2}(V_t + c_H + z_b - z_t)\}$. Plugging it into (2), $p^i_{bu} - p^i_{ec} = \frac{1}{2}\{\min\{V_b, \frac{1}{2}(V_t + c_H + z_b - z_t)\} + c_H + z_b - z_t\} > \frac{1}{2}\{\min\{V_b, \frac{1}{2}(V_t + V_b)\} + V_b\} = \min\{V_b, \frac{1}{4}V_t + \frac{3}{4}V_b\} > V_t$, since $z_b - z_t > V_b - c_H$. Thus, it contradicts. Suppose $p^i_{bu} - p^i_{ec} = V_b$. Then, by (3) and Lemma 1, $p^j_{bu} - p^j_{ec} = V_b$. Plugging it into (2), $p^i_{bu} - p^i_{ec} = \frac{1}{2}(V_b + c_H + z_b - z_t) > V_b$. It contradicts. By Lemma 1, $p^i_{bu} - p^i_{ec} > V_b$ is dominated by $p^i_{bu} - p^i_{ec} = V_b$. Hence, as long as $z_b - z_t > V_b - c_H$, $p^{i*}_{bu} = p^{i*}_{ec} + V_b$, $i = A, B$. ■

Proof of Theorem 1. Let $z_b - z_t \leq V_b - c_H$. Temporarily, assume that each airline solves the maximization problem for each class service independently. Then, each airline's equilibrium prices are $p^i_{bu} = c + c_H + z_b$ and $p^i_{ec} = c + z_t$, $i = A, B$. Note that the self-selection constraint does not bind, $p^i_{bu} - p^i_{ec} = c_H + z_b - z_t \leq V_b$, $i = A, B$. Hence, when $z_b - z_t \leq V_b - c_H$, $p^{i*}_{bu} = c + c_H + z_b$ and $p^{i*}_{ec} = z_t$, $i = A, B$.

Let $z_b - z_t > V_b - c_H$. By Lemma 2, $p^{i*}_{bu} = p^{i*}_{ec} + V_b$, $i = A, B$. Substituting it into (1), the airline i's profit maximization problem is

$$\max_{\{p^i_{ec}\}} \pi^i = \frac{N}{1+\beta}\{\beta(\frac{z_b + p^j_{ec} - p^i_{ec}}{2z_b})\left(p^i_{ec} + V_b - c - c_H\right) + (\frac{z_t + p^j_{ec} - p^i_{ec}}{2z_t})\left(p^i_{ec} - c\right)\}. \tag{A.4}$$

Then, the equilibrium prices are obtained from (4). ■

Proof of Theorem 3. Let $z_b - z_t \leq V_b - c_H$. Temporarily, assume that airline A's self-selection constraint does not bind. Then, given that airline B provides only economy class service, airline A's profit maximization problem is

$$\max_{\{p^A_{bu},\, p^A_{ec}\}} \pi^A = \frac{N}{1+\beta}\{\beta(\frac{z_b + V_b + p^B_{ec} - p^A_{bu}}{2z_b})(p^A_{bu} - c - c_H) + (\frac{z_t + p^B_{ec} - p^A_{ec}}{2z_t})\left(p^A_{ec} - c\right)\}. \tag{A.5}$$

From the FOCs,

$$p^A_{bu}(p^B_{ec}) = \frac{1}{2}(z_b + V_b + p^B_{ec} + c + c_H) \tag{A.6}$$

and

$$p^A_{ec}(p^B_{ec}) = \frac{1}{2}(z_t + p^B_{ec} + c). \tag{A.7}$$

Airline B's profit maximization problem is

$$\max_{\{p^B_{bu},\, p^B_{ec}\}} \pi^B = \frac{N}{1+\beta}\{\beta(\frac{z_b - V_b + p^A_{bu} - p^B_{ec}}{2z_b})\left(p^B_{ec} - c_E\right) + (\frac{z_t + p^A_{ec} - p^B_{ec}}{2z_t})\left(p^B_{ec} - c_E\right)\}. \tag{A.8}$$

From the FOC,

$$p^B_{ec}(p^A_{bu}, p^A_{ec}) = \frac{(\beta+1)z_b z_t + \beta z_t(p^A_{bu} - V_b) + z_b p^A_{ec}}{2(\beta z_t + z_b)} + \frac{c_E}{2}. \tag{A.9}$$

From (A.6), (A.7) and (A.9), $p^A_{bu} - p^A_{ec} = \frac{1}{2}(V_b + z_b - z_t + c_H) \leq V_b$. That is, it is consistent with the above assumption that airline A's self-selection constraint does not bind. Hence, from (A.6), (A.7) and (A.9), we have $p^{A*}_{bu} = c - \frac{c-c_E}{3} + \frac{c_H+V_b}{2} + \frac{1}{2}(z_b + \frac{(1+\beta)z_b z_t}{(z_b+\beta z_t)}) - \frac{\beta(V_b-c_H)z_t}{6(z_b+\beta z_t)}$, $p^{A*}_{ec} = c - \frac{c-c_E}{3} + \frac{1}{2}(z_t + \frac{(1+\beta)z_b z_t}{(z_b+\beta z_t)}) - \frac{\beta(V_b-c_H)z_t}{6(z_b+\beta z_t)}$ and $p^{B*}_{ec} = c_E - \frac{c_E-c}{3} + \frac{(1+\beta)z_b z_t}{z_b+\beta z_t} - \frac{\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)}$.

Let $z_b - z_t > V_b - c_H$. By Lemma 2, $p^{A*}_{bu} - p^{A*}_{ec} = V_b$. Plugging it into (A.5), airline A's profit maximization problem becomes

$$\begin{aligned} \max_{\{p^A_{ec}\}} \pi^A = \frac{N}{1+\beta}\{\beta(\frac{z_b + p^B_{ec} - p^A_{ec}}{2z_b})\big(p^A_{ec} + V_b - c - c_H\big) \\ +(\frac{z_t + p^B_{ec} - p^A_{ec}}{2z_t})\,\big(p^A_{ec} - c\big)\}. \end{aligned} \tag{A.10}$$

From the FOCs,

$$p^A_{ec} = \frac{1}{2}\left(p^B_{ec} + c\right) + \frac{(1+\beta)z_b z_t}{2(z_b+\beta z_t)} + \frac{\beta(c_H - V_b)z_t}{2(z_b+\beta z_t)} \tag{A.11}$$

and

$$p^B_{ec} = \frac{1}{2}\left(p^A_{ec} + c_E\right) + \frac{(\beta+1)z_b z_t}{2(z_b+\beta z_t)}. \tag{A.12}$$

Hence, from (A.9), (A.11) and (A.12), we have $p^{A*}_{bu} = c - \frac{c-c_E}{3} + \frac{(1+\beta)z_b z_t}{z_b+\beta z_t} - \frac{2\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)} + V_b$, $p^{A*}_{ec} = c - \frac{c-c_E}{3} + \frac{(1+\beta)z_b z_t}{z_b+\beta z_t} - \frac{2\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)}$ and $p^{B*}_{ec} = c_E - \frac{c_E-c}{3} + \frac{(1+\beta)z_b z_t}{z_b+\beta z_t} - \frac{\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)}$. ■

Proof of Theorem 5. Let $z_b - z_t \leq V_b - c_H$. $\tilde{D}^{A*}_{bu}(3) - \tilde{D}^{A*}_{ec}(3) = -\frac{(1+\beta)(z_b-z_t)}{4(z_b+\beta z_t)} + \frac{(V_b-c_H)}{4(z_b+\beta z_t)} + \frac{(z_b+2\beta)z_t(V_b-c_H)}{12(z_b+\beta z_t)z_b} + \frac{(z_b-z_t)(c-c_E)}{6z_b z_t} \geq \frac{(z_b z_t+2\beta z_t)(z_b-z_t)}{12(z_b+\beta z_t)z_b} + \frac{(z_b-z_t)\{2(c-c_E)-3\beta\}}{12 z_b z_t} > 0$, since $z_b - z_t \leq V_b - c_H$ and $2(c-c_E) - 3\beta = \frac{1}{4}$. Also, note that $\frac{\partial D^{A*}_{bu}(3)}{\partial z_t} =$

$\frac{3(1+\beta)z_b-\beta(V_b-c_H)}{12(z_b+\beta z_t)^2} > 0$. $\frac{\partial D_{ec}^{A*}(3)}{\partial z_t}|_{z_t=z_b} < 0$, $\frac{\partial D_{ec}^{A*}(3)}{\partial z_t}|_{z_t=\tilde{z}_t} = 0$ and $\frac{\partial^2 D_{ec}^{A*}(3)}{(\partial z_t)^2} < 0$ where $\tilde{z}_t = \sqrt{\frac{3\beta(1+\beta)z_b-\beta^2(V_b-c_H)}{2(c-c_E)}} - \beta$, since $\frac{\partial D_{ec}^{A*}(3)}{\partial z_t} = \frac{2(c-c_E)(\frac{z_b}{z_t}+\beta)^2-3\beta(1+\beta)z_b+\beta^2(V_b-c_H)}{12(z_b+\beta z_t)^2}$.

Let $z_b - z_t > V_b - c_H$. Substituting $c - c_E = 0.5, \beta = 0.25$, $z_b = 4$ and $z_b - z_t > V_b - c_H$, $\tilde{D}_{bu}^{A*}(3) - \tilde{D}_{ec}^{A*}(3) = \frac{\{(z_b+\beta z_t)(c-c_E)-\beta(V_b-c_H)z_t\}(z_b-z_t)}{6(z_b+\beta z_t)z_b z_t} > \frac{\{(z_b+\beta z_t)(c-c_E)-\beta(z_b-z_t)z_t\}(z_b-z_t)}{6(z_b+\beta z_t)z_b z_t} = \frac{\{(4+0.25z_t)*0.5-0.25(4-z_t)z_t\}(z_b-z_t)}{6(z_b+\beta z_t)z_b z_t} > 0, \forall z_t$. Note that $\frac{\partial D_{ec}^{A*}(3)}{\partial z_t} = \frac{(z_b+\beta z_t)^2(c-c_E)-\beta^2(V_b-c_H)z_t^2}{6(z_b+\beta z_t)^2 z_t^2} > 0$ and $\frac{\partial D_{bu}^{A*}(3)}{\partial z_t} = \frac{\beta(V_b-c_H)z_b}{3(z_b+\beta z_t)^2} > 0$. ■

A.2 Equilibrium profits, prices, and demands in the second stage

A.2.1 Case 1: both choose normal airplanes.

$$\pi^{i*}_{B/E}(1) = \frac{N}{1+\beta}[\beta\left\{\frac{z_b + p^j_{bu}(1) - p^i_{bu}(1)}{2z_b}\right\}\left(p^i_{bu}(1) - c - c_H\right)$$
$$+\left\{\frac{z_t + p^j_{ec}(1) - p^i_{ec}(1)}{2z_t}\right\}\left(p^i_{ec}(1) - c\right)],$$

where $i = A, B$ and $j \neq i$.

No Binding Case: $z_b - z_t < V_b - c_H$

$$p^{i*}_{bu}(1) = c + c_H + z_b,\ p^{i*}_{ec}(1) = c + z_t,$$
$$D^{i*}_{bu}(1) = \frac{\beta N}{2(1+\beta)},\ D^{i*}_{ec}(1) = \frac{N}{2(1+\beta)},$$
$$\pi^{i*}_{B/E}(1) = \frac{N}{1+\beta}\left\{\frac{\beta z_b}{2} + \frac{z_t}{2}\right\},\ i = A, B.$$

Binding Case: $z_b - z_t > V_b - c_H$

$$p^{i*}_{bu}(1) = c + V_b + \frac{\{(1+\beta)z_b - \beta(V_b - c_H)\}z_t}{z_b + \beta z_t},$$
$$p^{i*}_{ec}(1) = c + \frac{\{(1+\beta)z_b - \beta(V_b - c_H)\}z_t}{z_b + \beta z_t},$$
$$D^{i*}_{bu}(1) = \frac{\beta N}{2(1+\beta)},\ D^{i*}_{ec}(1) = \frac{N}{2(1+\beta)},$$
$$\pi^{i*}_{B/E}(1) = \frac{N}{1+\beta}[\frac{\beta\{(1+\beta)z_t + (V_b - c_H)\}z_b}{2(z_b + \beta z_t)}$$
$$+\frac{\{(1+\beta)z_b - \beta(V_b - c_H)\}z_t}{2(z_b + \beta z_t)}],\ i = A, B.$$

A.2.2 Case 2: both choose low-cost carriers.

$$\pi_E^{i*}(2) = \frac{N}{1+\beta}\left[\beta\left\{\frac{z_b + p_{ec}^j(2) - p_{ec}^i(2)}{2z_b}\right\}\left(p_{ec}^i(2) - c_E\right) + \right.$$
$$\left. + \left\{\frac{z_t + p_{ec}^j(2) - p_{ec}^i(2)}{2z_t}\right\}\left(p_{ec}^i(2) - c_E\right)\right],$$

where $i = A, B$ and $j \neq i$.

$$\begin{aligned}
p_{ec}^{i*}(2) &= c_E + \frac{(1+\beta)z_b z_t}{z_b + \beta z_t}, \\
D_{bu}^{i*}(2) &= \frac{\beta N}{2(1+\beta)},\ D_{ec}^{i*}(2) = \frac{N}{2(1+\beta)}, \\
\pi_E^{i*}(2) &= \frac{N}{2}\left(\frac{(1+\beta)z_b z_t}{z_b + \beta z_t}\right),\ i = A, B.
\end{aligned}$$

A.2.3 Case 3: one chooses a normal airplane and the other a low-cost carrier.

$$\begin{aligned}
\pi_{B/E}^{A*}(3) &= \frac{N}{1+\beta}[\beta\left\{\frac{z_b + V_b + p_{ec}^B(3) - p_{bu}^A(3)}{2z_b}\right\}\left(p_{bu}^A(3) - c - c_H\right) \\
&\quad + \left\{\frac{z_t + p_{ec}^B(3) - p_{ec}^A(3)}{2z_t}\right\}\left(p_{ec}^A(3) - c\right)], \\
\pi_E^{B*}(3) &= \frac{N}{1+\beta}[\beta\left\{\frac{z_b - V_b + p_{bu}^A(3) - p_{ec}^B(3)}{2z_b}\right\}\left(p_{ec}^B(3) - c - c_H\right) \\
&\quad + \left\{\frac{z_t + p_{ec}^A(3) - p_{ec}^B(3)}{2z_t}\right\}\left(p_{ec}^B(3) - c\right)].
\end{aligned}$$

No Binding Case: $z_b - z_t < V_b - c_H$

$$
\begin{aligned}
p_{bu}^{A*}(3) &= \frac{2c+c_E}{3} + \frac{c_H+V_b}{2} + \frac{1}{2}(z_b + \frac{(1+\beta)z_b z_t}{(z_b+\beta z_t)}) - \frac{\beta(V_b-c_H)z_t}{6(z_b+\beta z_t)}, \\
p_{ec}^{A*}(3) &= \frac{2c+c_E}{3} + \frac{1}{2}(z_t + \frac{(1+\beta)z_b z_t}{(z_b+\beta z_t)}) - \frac{\beta(V_b-c_H)z_t}{6(z_b+\beta z_t)}, \\
p_{ec}^{B*}(3) &= \frac{c+2c_E}{3} + \frac{(1+\beta)z_b z_t}{z_b+\beta z_t} - \frac{\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)}. \\
D_{bu}^{A*}(3) &= \frac{\beta N}{2(1+\beta)z_b}\{\frac{1}{2}\left(z_b + \frac{(1+\beta)z_b z_t}{(z_b+\beta z_t)}\right) \\
&\qquad + \frac{(3z_b+2\beta z_t)(V_b-c_H)}{6(z_b+\beta z_t)} - \frac{c-c_E}{3}\}, \\
D_{ec}^{A*}(3) &= \frac{N}{2(1+\beta)z_t}\{\frac{1}{2}\left(z_t + \frac{(1+\beta)z_b z_t}{z_b+\beta z_t}\right) \\
&\qquad - \frac{\beta(V_b-c_H)z_t}{6(z_b+\beta z_t)} - \frac{c-c_E}{3}\}.
\end{aligned}
$$

$$
\begin{aligned}
\pi_{B/E}^{A*}(3) &= \frac{N}{1+\beta}[\frac{\beta}{2z_b}\{\frac{1}{2}\left(z_b + \frac{(1+\beta)z_b z_t}{(z_b+\beta z_t)}\right) \\
&\qquad + \frac{(3z_b+2\beta z_t)(V_b-c_H)}{6(z_b+\beta z_t)} - \frac{c-c_E}{3}\}^2 \\
&\quad + \frac{1}{2z_t}\{\frac{1}{2}\left(z_t + \frac{(1+\beta)z_b z_t}{z_b+\beta z_t}\right) - \frac{\beta(V_b-c_H)z_t}{6(z_b+\beta z_t)} - \frac{c-c_E}{3}\}^2], \\
\pi_E^{B*}(3) &= \frac{N}{1+\beta}[\frac{\beta}{2z_b}\{\frac{1}{2}\left(3z_b - \frac{(1+\beta)z_b z_t}{z_b+\beta z_t}\right) - \frac{(3z_b+2\beta z_t)(V_b-c_H)}{6(z_b+\beta z_t)} \\
&\qquad + \frac{c-c_E}{3}\} \times \left\{\frac{(1+\beta)z_b z_t}{z_b+\beta z_t} - \frac{\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)} + \frac{c-c_E}{3}\right\} \\
&\quad + \frac{1}{2z_t}\left\{\frac{1}{2}\left(3z_t - \frac{(1+\beta)z_b z_t}{z_b+\beta z_t}\right) + \frac{\beta(V_b-c_H)z_t}{6(z_b+\beta z_t)} + \frac{c-c_E}{3}\right\} \\
&\qquad \times \left\{\frac{(1+\beta)z_b z_t}{z_b+\beta z_t} - \frac{\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)} + \frac{c-c_E}{3}\right\}].
\end{aligned}
$$

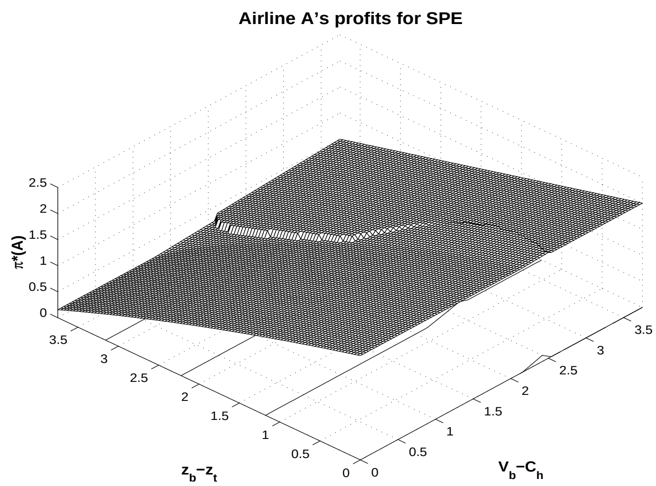
Binding Case: $z_b - z_t > V_b - c_H$

$$\begin{aligned}
p_{bu}^{A*}(3) &= \frac{2c+c_E}{3} + \frac{(1+\beta)z_b z_t}{z_b+\beta z_t} - \frac{2\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)} + V_b, \\
p_{ec}^{A*}(3) &= \frac{2c+c_E}{3} + \frac{(1+\beta)z_b z_t}{z_b+\beta z_t} - \frac{2\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)} \\
p_{ec}^{B*}(3) &= \frac{c+2c_E}{3} + \frac{(1+\beta)z_b z_t}{z_b+\beta z_t} - \frac{\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)}. \\
D_{bu}^{A*}(3) &= \frac{\beta N}{2z_b}\left\{z_b + \frac{\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)} - \frac{c-c_E}{3}\right\}, \\
D_{ec}^{A*}(3) &= \frac{N}{2z_t}\left\{z_t + \frac{\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)} - \frac{c-c_E}{3}\right\}.
\end{aligned}$$

$$\begin{aligned}
\pi_{B/E}^{A*}(3) = \frac{N}{1+\beta}[&\frac{\beta}{2z_b}\left\{z_b + \frac{\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)} - \frac{c-c_E}{3}\right\} \\
&\times\left\{\frac{(1+\beta)z_b z_t}{(z_b+\beta z_t)} - \frac{2\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)} - \frac{c-c_E}{3} + V_b - c_H\right\} \\
&+\frac{1}{2z_t}\left\{z_t + \frac{\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)} - \frac{c-c_E}{3}\right\} \\
&\times\left\{\frac{(1+\beta)z_b z_t}{z_b+\beta z_t} - \frac{2\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)} - \frac{c-c_E}{3}\right\}], \\
\pi_{E}^{B*}(3) = \frac{N}{1+\beta}[&\frac{\beta}{2z_b}\left\{z_b - \frac{\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)} + \frac{c-c_E}{3}\right\} \\
&\times\left\{\frac{(1+\beta)z_b z_t}{z_b+\beta z_t} - \frac{\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)} + \frac{c-c_E}{3}\right\} \\
&+\frac{1}{2z_t}\left\{z_t - \frac{\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)} + \frac{c-c_E}{3}\right\} \\
&\times\left\{\frac{(1+\beta)z_b z_t}{z_b+\beta z_t} - \frac{\beta(V_b-c_H)z_t}{3(z_b+\beta z_t)} + \frac{c-c_E}{3}\right\}].
\end{aligned}$$

A.3 Figures

Figure A.1: Airline A and B's profits for SPE



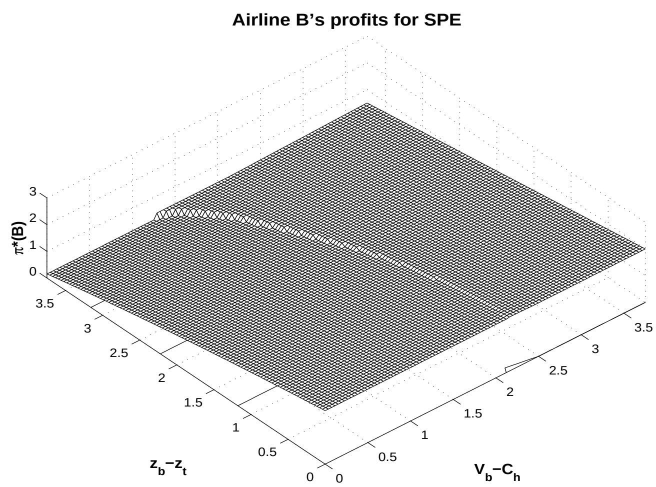


Figure A.2: Airline A's business and economy prices for SPE

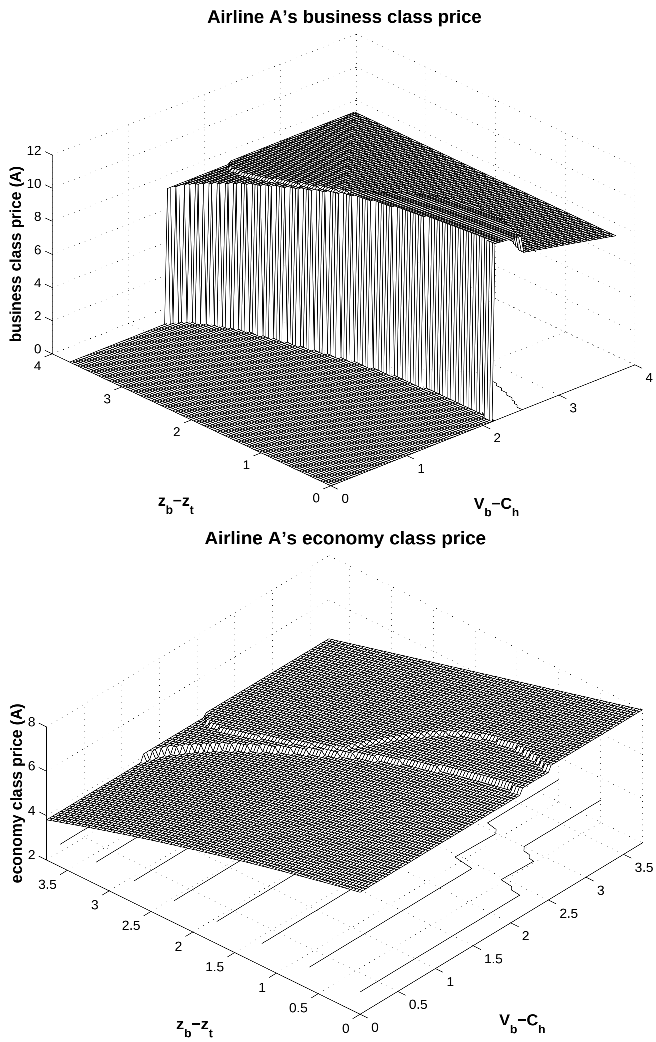


Figure A.3: Airline B's economy price for SPE

Figure A.4: Demands for airline A's business and economy classes for SPE

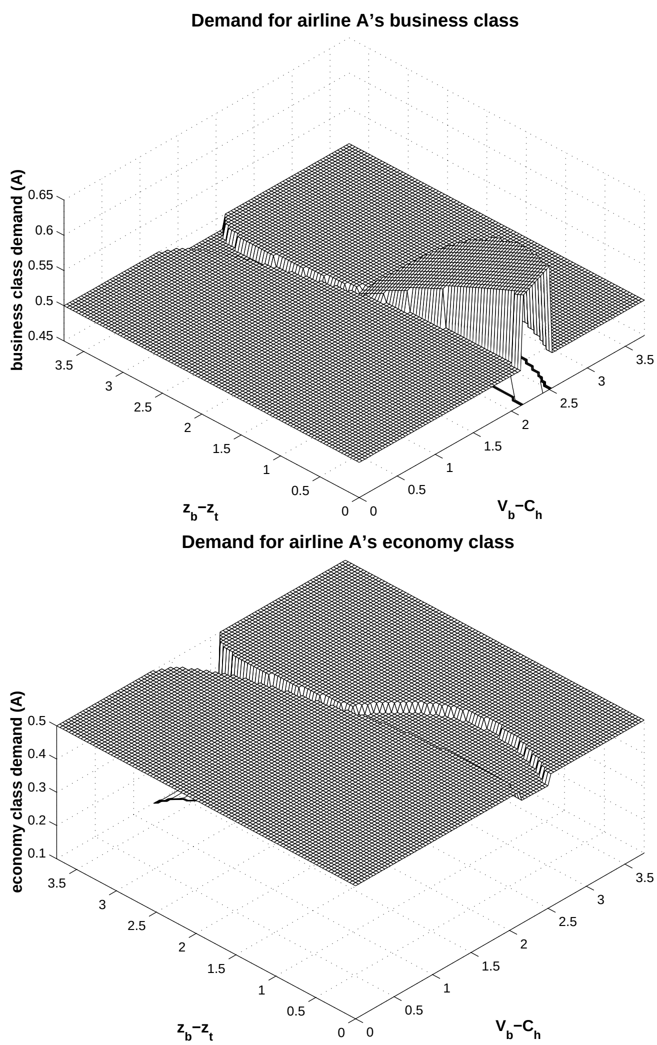


Figure A.5: SPE and Comparison between airline A and B's profits for the SPE with Case 3 when $\beta = 0.35$

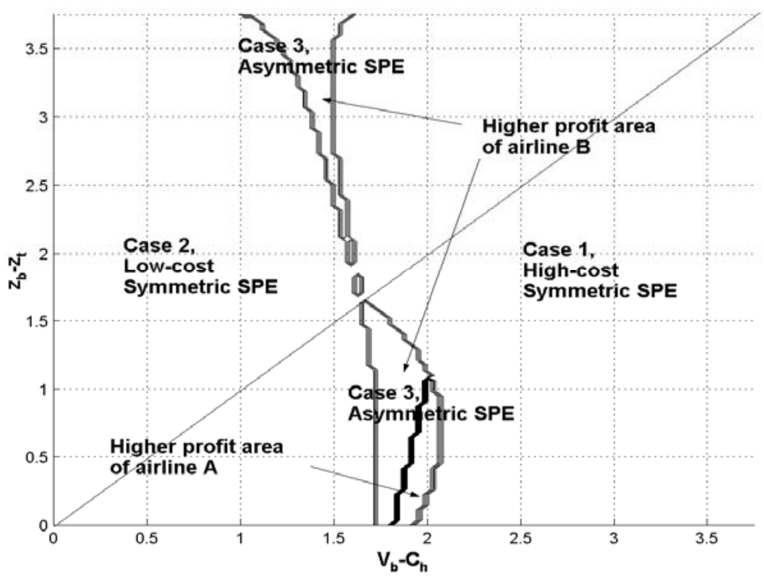


Figure A.6: Equilibria with cost structures maximizing social welfare when $\beta = 0.35$

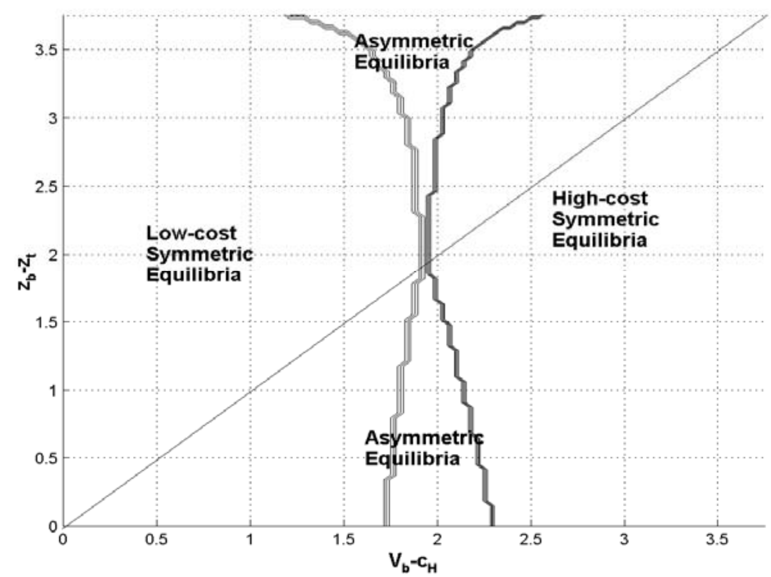


Figure A.7: SPE and Comparison between airline A and B's profits for the SPE with Case 3 when $c - c_E = 0.6$

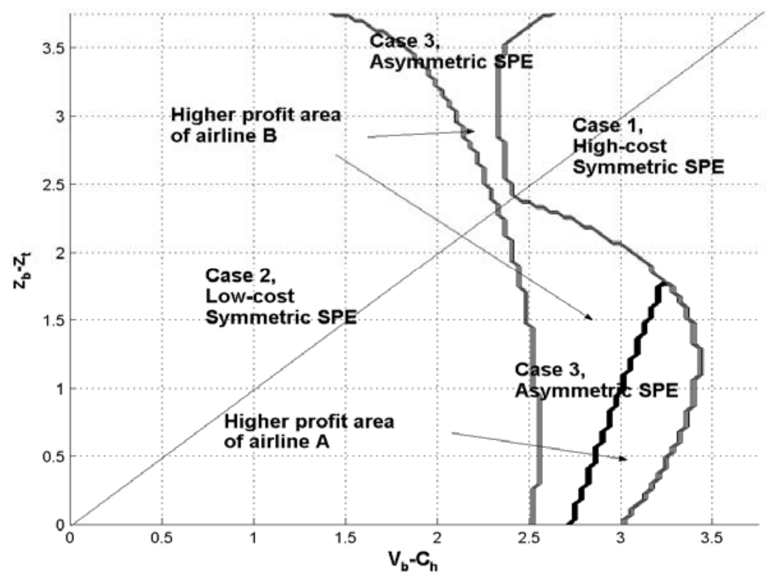


Figure A.8: Equilibria with cost structures maximizing social welfare when $c - c_E = 0.6$

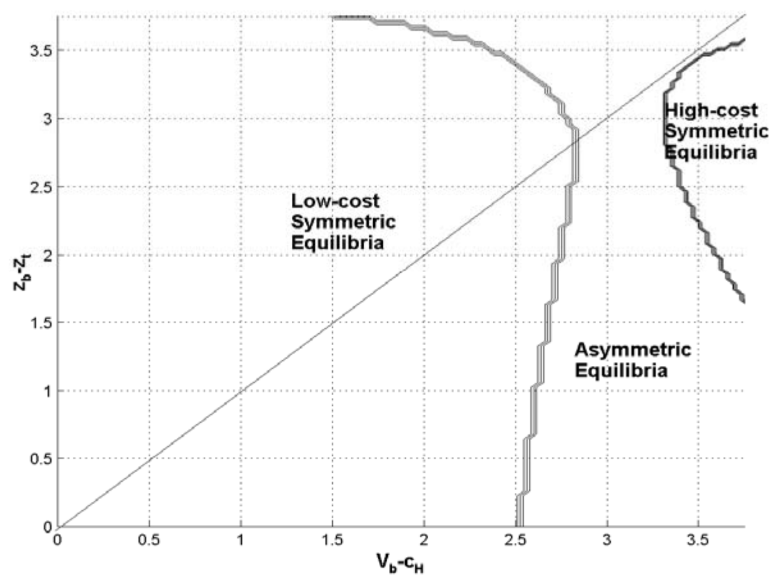


Figure A.9: SPE and Comparison between airline A and B's profits for the SPE with Case 3 when $z_t = 1$

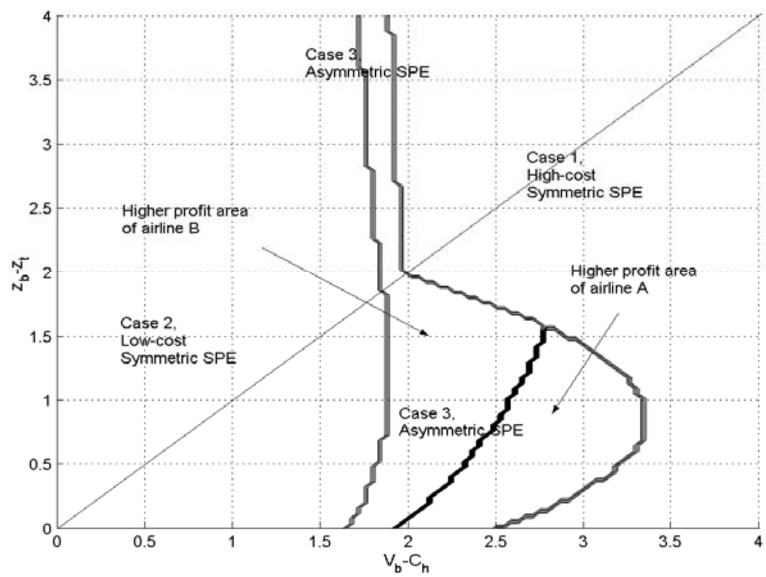
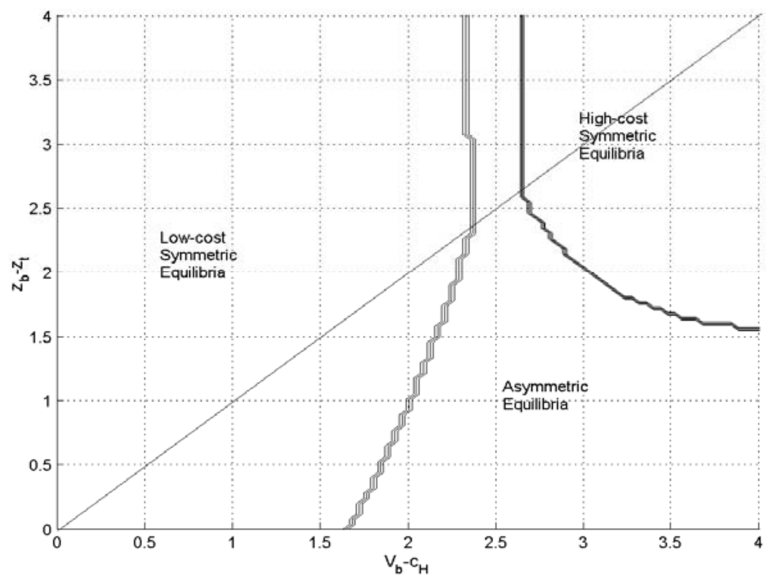


Figure A.10: Equilibria with cost structures maximizing social welfare when $z_t = 1$



Appendix B

Appendix of Chapter 2

B.1 Tables

Table B.1: Bank characteristics

Bank characteristics	1994	1995	1996
Branch numbers/bank	144.5	159.8	177.1
No. of employees per branch/bank	17.5	16.5	14.5
Per. of branches serving foreign exchange/bank	53	52	66
Per. of 1 year old branches/bank	7.8	9.8	8.6
Per. of 2 year old branches/bank	12.8	11.1	11.3
Per. of 3 year old branches/bank	10.2	10.7	9.6

Table B.2: Market characteristics

	Markets in metropolitan areas	Regional cities
Population	408180	214324
Market area size	51.34	113.78

Table B.3: Number of banks and branches in two types of markets

	Metropolitan areas			Regional cities		
	1994	1995	1996	1994	1995	1996
Number of branches	50.0	52.3	56.1	25.4	29.9	34.0
Number of banks	10.4	10.8	11.2	6.6	7.5	7.9

Table B.4: Demand estimation with GMM

	IV Logit		Nested Logit	
Explanatory variables	Coefficient	t-value	Coefficient	t-value
Deposit interest rate	0.474	(9.80)	0.197	(5.99)
Branch density	0.792	(6.40)	0.672	(9.85)
Branch density squared	-0.203	(-5.01)	-0.150	(-5.97)
Employees per branch	0.043	(0.97)	0.097	(4.17)
Per. of serving foreign exchange	0.095	(11.87)	0.058	(10.26)
log(bank's age)	0.507	(16.83)	0.131	(4.12)
Per. of three-year old branches	-0.271	(-3.94)	-0.149	(-4.18)
Per. of two-year old branches	-0.658	(-9.63)	-0.320	(-7.79)
Per. of one-year old branches	-1.294	(-12.94)	-0.587	(-8.36)
Local bank dummy	1.082	(17.10)	0.243	(4.04)
Year dummy (94)	-7.549	(-15.94)	-2.779	(-6.65)
Year dummy (95)	-7.729	(-15.85)	-2.832	(-6.59)
Year dummy (96)	-7.691	(-16.25)	-2.794	(-6.58)
$\ln(s_{j\|g})$	-	-	0.616	(15.70)

Table B.5: Supply estimation with GMM

	IV Logit		Nested Logit	
Explanatory variables	Coefficient	t-value	Coefficient	t-value
Constant (deposit rate)	0.837	(3.04)	0.863	(1.61)
Number of branches (branch)	0.119	(3.69)	0.325	(3.87)
log(bank's age) (branch)	-0.094	(-2.91)	-0.188	(-2.45)
Regional bank dummy (branch)	-1.366	(-4.07)	-3.073	(-3.60)
Year dummy (94) (branch)	0.497	(3.32)	0.863	(2.56)
Year dummy (95) (branch)	0.520	(3.43)	0.909	(2.65)
Year dummy (96) (branch)	0.578	(3.60)	1.029	(2.77)

Table B.6: Average number of branches for three categories of banks

	1994	1995	1996
6 Big banks	327	360	411
Medium banks	90	105	116
Regional banks	100	108	121

Table B.7: Average branch density in two types of markets

	Metropolitan areas			Regional cities		
	1994	1995	1996	1994	1995	1996
6 Big banks	0.218	0.224	0.234	0.024	0.027	0.031
Medium banks	0.106	0.108	0.110	0.015	0.016	0.016
Regional banks	0.309	0.317	0.328	0.066	0.073	0.079

Table B.8: Sum of market shares for three categories of banks

	1994	1995	1996
6 Big banks	40.28%	39.00%	38.40%
Medium banks	16.46%	18.01%	19.31%
Regional banks	10.32%	10.77%	10.65%

Table B.9: Deposit amount per branch for three categories of banks

	1994	1995	1996
6 Big banks	422.47	458.19	498.27
Medium banks	470.08	546.37	666.43
Regional banks	211.95	253.01	280.65

Table B.10: Average estimated markups for three categories of banks (Logit model)

bank	1994	1995	1996
Big 6 banks	2.303	2.299	2.297
Medium banks	2.196	2.200	2.203
Regional banks	2.849	2.831	2.804

Table B.11: Average estimated markups for three categories of banks (Nested Logit model)

bank	1994	1995	1996
Big 6 banks	2.316	2.308	2.303
Medium banks	2.169	2.174	2.177
Regional banks	3.210	3.143	3.085

Table B.12: Average estimated price elasticities for three categories of banks (Logit model)

bank	1994	1995	1996
Big 6 banks	3.258	3.373	3.250
Medium banks	3.911	4.033	3.772
Regional banks	2.557	2.719	2.708

Table B.13: Average estimated price elasticities for three categories of banks (Nested Logit model)

bank	1994	1995	1996
Big 6 banks	3.241	3.360	3.241
Medium banks	3.960	4.082	3.817
Regional banks	2.280	2.458	2.467

Table B.14: Average estimated cross price elasticities for three categories of banks (Logit model)

Price change	Demand change	1994	1995	1996
Big 6 banks	Big 6 banks	-0.257	-0.258	-0.246
	Medium banks	-0.248	-0.246	-0.232
	Regional banks	-0.170	-0.173	-0.161

Price change	Demand change	1994	1995	1996
Medium banks	Big 6 banks	-0.091	-0.102	-0.103
	Medium banks	-0.104	-0.113	-0.111
	Regional banks	-0.039	-0.053	-0.061

Price change	Demand change	1994	1995	1996
Regional banks	Big 6 banks	-0.020	-0.022	-0.021
	Medium banks	-0.020	-0.023	-0.024
	Regional banks	-0.003	-0.003	-0.003

Table B.15: Average estimated cross price elasticities for three categories of banks (Nested Logit model)

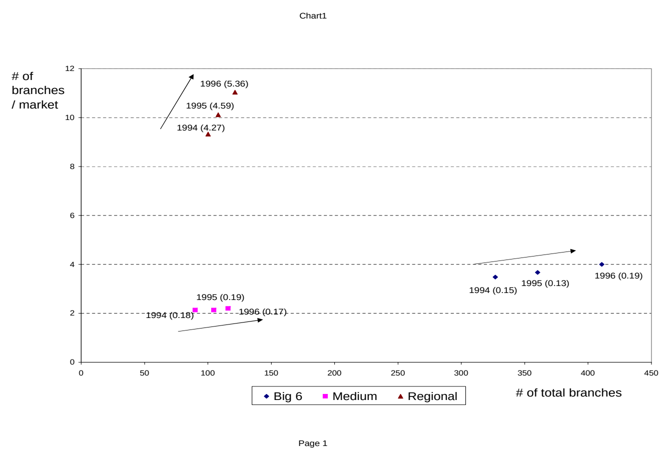
Price change	Demand change	1994	1995	1996
Big 6 banks	Big 6 banks	-0.341	-0.341	-0.322
	Medium banks	-0.326	-0.322	-0.303
	Regional banks	-0.242	-0.244	-0.225

Price change	Demand change	1994	1995	1996
Medium banks	Big 6 banks	-0.119	-0.133	-0.134
	Medium banks	-0.136	-0.148	-0.146
	Regional banks	-0.054	-0.072	-0.082

Price change	Demand change	1994	1995	1996
Regional banks	Big 6 banks	-0.028	-0.030	-0.029
	Medium banks	-0.026	-0.030	-0.032
	Regional banks	-0.003	-0.003	-0.003

B.2 Figures

Figure B.1: Branch networks and deposit rates across three categories of banks



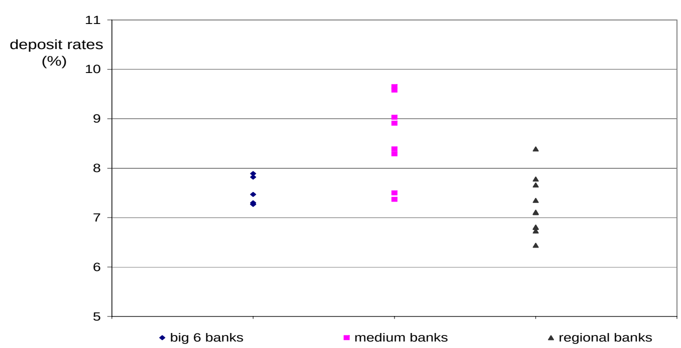


Figure B.2: Deposit interest rates and price elasticities (Logit model)

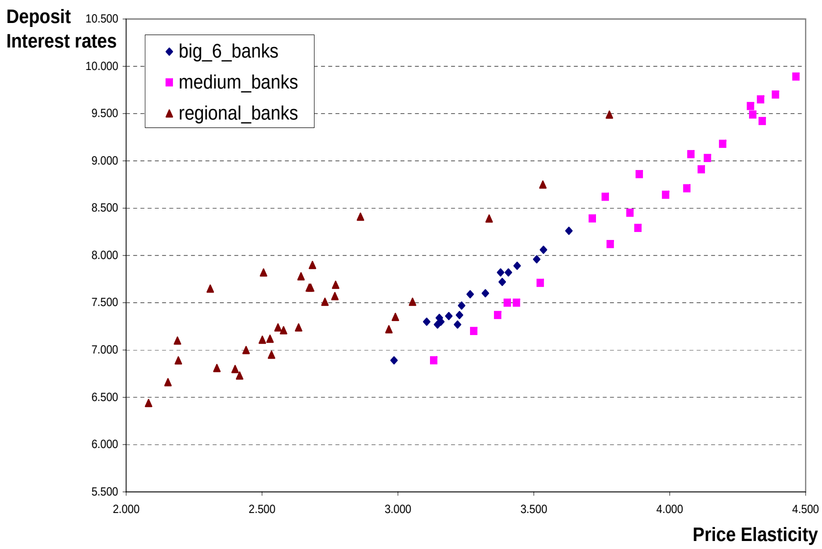


Figure B.3: Deposit interest rates and price elasticities (Nested Logit model)

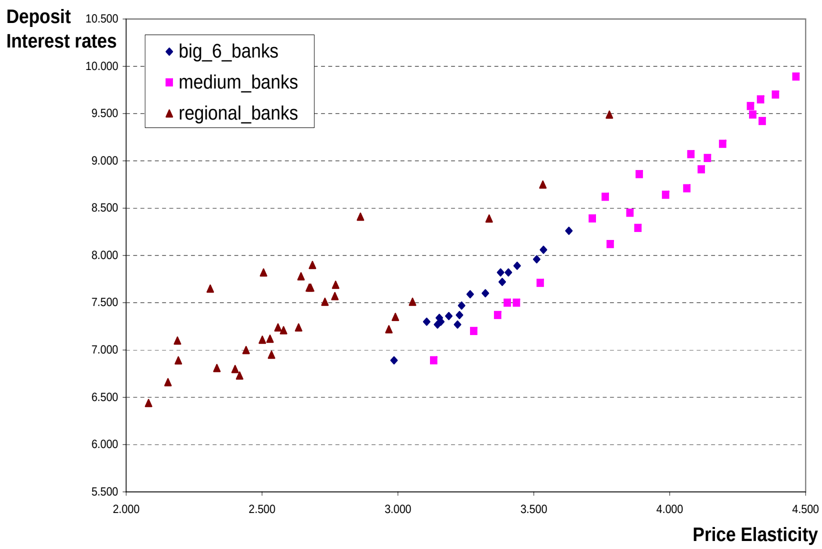


Figure B.4: Deposit interest rates and Lerner index (Logit model)

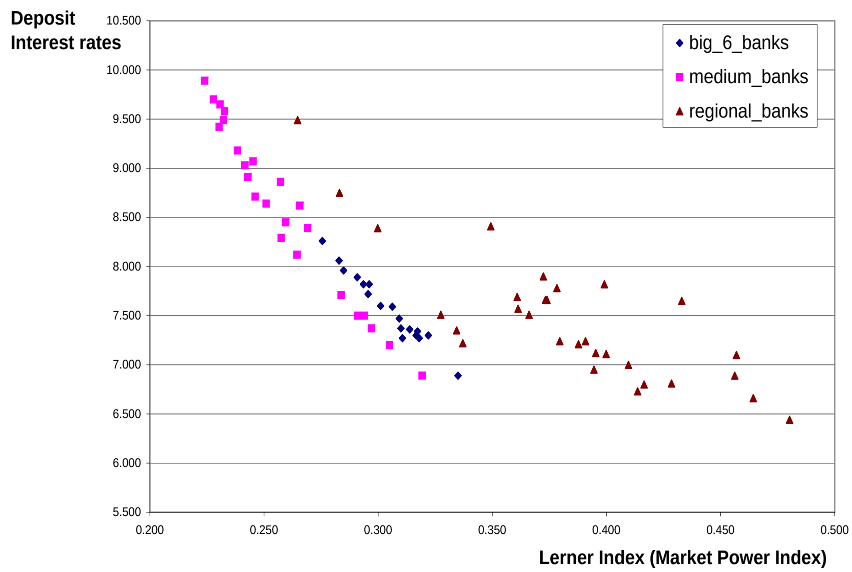


Figure B.5: Deposit interest rates and Lerner index (Nested Logit model)

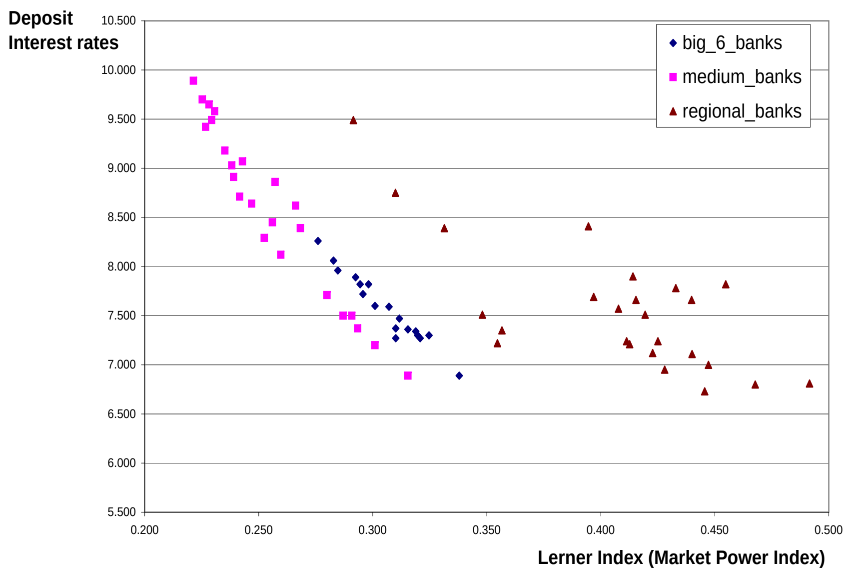


Figure B.6: branch elasticities based across markets (Logit model)

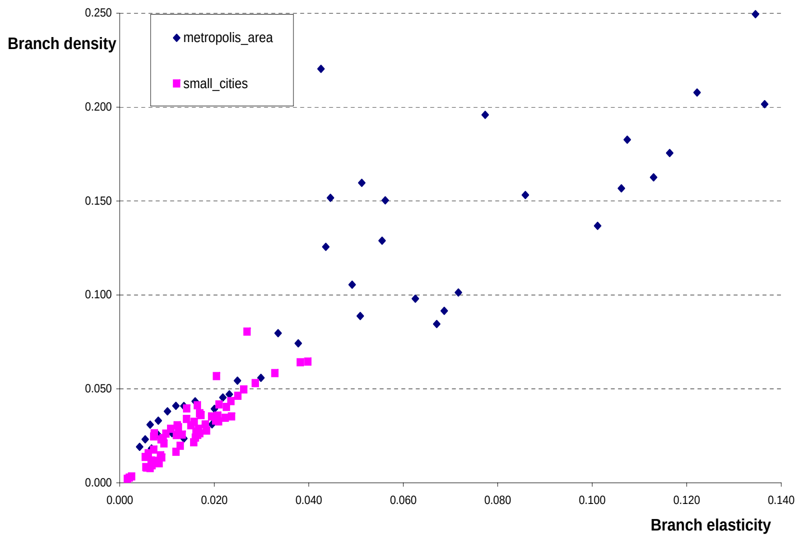


Figure B.7: branch branch elasticities across banks (Logit model)

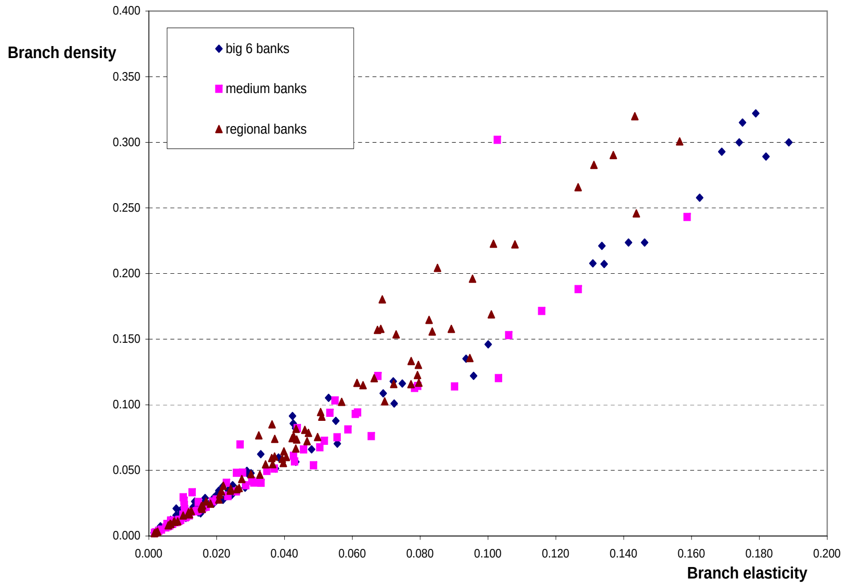
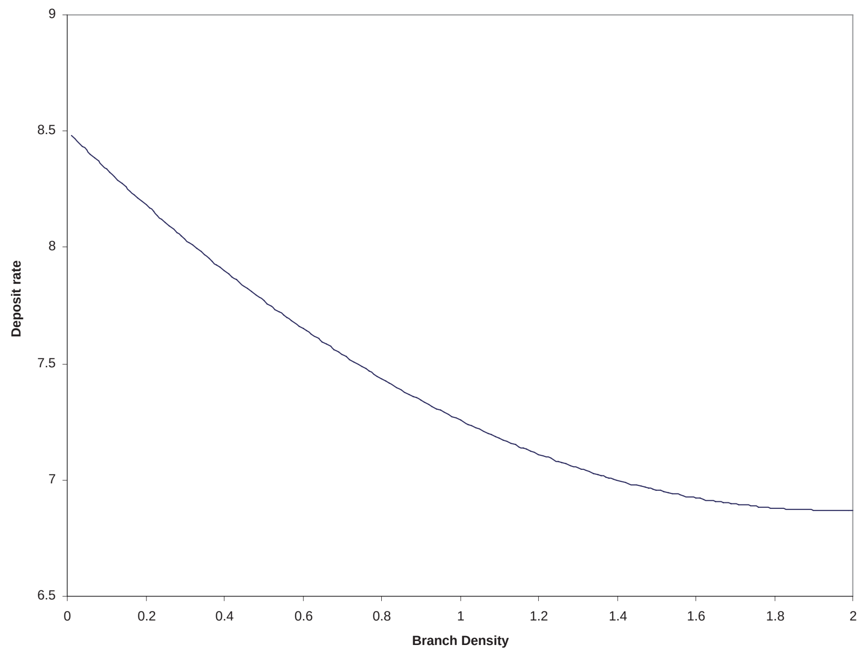


Figure B.8: Indifference Curve



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Vita

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This dissertation was typeset with LaTeX 2_ε[1] by the author.

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